

# Slug Control

Can ducks reliably provide slug control on a small farm?

Research Summary by Steve & Elizabeth Gabriel Wellspring Forest Farm & School



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## Background

Wellspring Forest Farm is a 50-acre agroforestry inspired farm and homestead. The farm is coowned and operated by Elizabeth and Steve Gabriel and we've been growing crops since 2011. We develop our operations systematically, analyzing resources and challenges of the site, our economic capacity, time, personal interest and market demands. We value that agroforestry offers opportunities for restoring the ecological health of the land while providing income for the farm.

Our main crop is mushrooms, which we sell to restaurants and through a CSA. We maintain a flock of 50 ducks that provide slug control to the shiitakes and nutrients to our gardens. We originally brought ducks onto the farm as a meat enterprise but determined that eggs would fit better with our goals long term. We sell eggs to local retail stores and restaurants. Since 2012, we have planted trees to eventually provide wind protection, fodder, shade and wood for our grazing sheep.

Sheep complemented the operation because our pasture is in need of regeneration and sheep are much more sustainable than mowing between the rows of tree crops. We expect to have around 28 sheep in 2016 and have a goal of managing about 20 ewes and 30 lambs each year from 2018 onward. Adding ducks to the sheep rotation, we hope further improve soil health, reduce sheep exposure to parasites and increase farm production.

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Ducks have always captured our imagination, and we enjoy being around them. We originally looked at raising meat ducks but settling on having ducks for their benefit to the farm landscape, for a small amount of egg production, and for personal enjoyment.

#### **NE SARE Project Links:**

**2012 – 2014** https://projects.sare.org/sare\_project/fne12-745/

2015 - 2018 https://projects.sare.org/project-reports/fne16-842/

#### Project 1: Integrating ducks into log-grown shiitake mushroom production for slug control and added yields

Log-grown shiitake mushrooms are a growing interest of many Northeast Farmers. Barriers to entering the market include the labor-intensive process, frequent slug problems, and that laying yards are situated in woodland areas, often far from normal farm routines.

Integration of meat ducks into the mushroom laying yard brings more yields for the farmer on a single trip, promotes effective slug control, and better utilizes forest ecosystems in the farm landscape. Ducks are an underappreciated farm asset with potential to sustainably manage pests while providing high-quality products for market. Little research has been done to demonstrate the potential of integrated duck farming in the Northeast.

SARE grant funds supported bringing 50 ducks into a 700-log commercial operation in 2012 and 2013, where efforts were focused on breed selection for temperament, foraging ability, and weight gain. In 2013, the operation increased to 1000 logs and the project focused on optimizing the system efficiency, forest improvement and profit. Throughout both seasons the mushroom yard, duck population, and forest ecosystem were monitored for health and productivity.



#### **KEY FINDINGS:**

- 1. Ducks can likely provide a level of pest control throughout the farm (including forests, fields, and gardens) and if rotated, do not appear to have adverse effects on the farm landscape.
- 2. Only one of the four breeds of duck we raised (Muscovy) gains sufficient weight to make a profit. A duck would need to get to at least 8 lbs in a season to make it economical under our model. 150 400 ducks would need to be raised per season to be economically viable.
- 3. Integrating ducks into the mushroom yard did appear to have a positive effect on reducing slug populations and thus mushroom damage, though the mix of variables (weather, temperatures, labor, etc) made it difficult to collect good data on the dynamics at play.
- 4. homestead practices. Read more about the farm at: <u>www.WellspringForestFarm.com.</u>



Figure 1: Concept for the forest polyculture, which emerged by "accident"

Research was conducted over two mushroom growing seasons (April through October), with the first season focusing on breed selection (2012), and the second season on system optimization (2013).

The overall goal of this farmer research project was to explore the interaction and relationship between the forest as a farm ecosystem, a log-grown shiitake operation and related pest problems (slugs), and ducks as a pest control agent/additional income stream. We wanted to see if a win-winwin situation could emerge; that the pest pressure on the shiitakes would be reduced, the ducks would be enjoyable to work with and profitable (for meat), and that the forest would not display any adverse impacts, but rather, positive ones. In 2012, we used fencing to set up three separate areas in the woods. Two areas enclosed different duck species for the entirety of the season, and one served as a control (no ducks). Each plot was about a quarter of an acre (see figure 3). Each area had approximately 200 - 250 logs, which was managed in 8 groups of about 20 logs per group. (Mushroom logs need 8 weeks of rest between soakings.)

Each week, we soaked a group from each of the three trial areas on the same day. After soaking and upon fruiting, we harvested the shiitakes and attempted to calculate percent slug damage from the three yards as a comparison of treatments. Because this system proved to be challenging, we switched methods in year two and ultimately were able to only make some general observations about the results with a few indicators of success.

The main research questions were as follows:

- 1. Are ducks effective and reliable slug control in log-grown mushroom cultivation?
- 2. Is the forest affected in any negative way from the presence of ducks?
- 3. Are ducks economically viable as an additional farm income stream?

In addition, though not formally researched and some may say challenging if not impossible to measure, the well-being and happiness of the birds was an important component of our system. Some people may disagree with raising animals for meat but we believe home meat production is a critical element to a sustainable food system in our climate and take pride in providing our animals with complete care and access to natural environments. We do not view these birds as commodities but as sentient beings that deserve respect and admiration. Duck happiness has to always be evident on our farm.



## YEAR ONE – 2012

#### **SUMMARY OF ACTIVITIES**

As a way to summarize the season, here is what we did, month-by-month:

#### **JANUARY - APRIL**

In the beginning months of 2012 we spent time talking to duck growers, researching material options and supplies, and ordering ducklings for a May delivery. After conversations with farmers

and Extension agents we decided to open the study to include four breeds including heritage ducks and that the season would conclude with a tasting event to see if consumers (or chefs) had a preference among breeds.

#### MAY

The ducklings arrived and were raised in metal stock tanks for 2 weeks, then given access to grass forage during the day for 2 more weeks.



All of the ducks purchased in 2012 were male, so to offer some consistency since were tracking their weight. Ducklings were given free choice of grain during this time and there were two groups, which would remain throughout the season:

Group #1: 10 Rouen, 15 Muscovy, 1 Chinese Goose (protection) Group #2: 10 Cayuga, 10 Swedish Blue, 1 African Goose (protection)

We only lost the Chinese Goose (strangled, sadly in the net fence) and one Rouen who also became entangled in some baling twine and had to be killed.

#### JUNE

In early June three yards were set up with logs: one for each group and one as a control. Each section had roughly 120 active logs. The duck house was also completed and put into place. The ducks moved into the site on June 10th, when we began taking data on mushroom yields, slug damage, duck weights, feed measurements, and any other notable observations. All the ducks were rationed at .4 lbs of feed per bird, per day over two feedings (recommended rate for meat ducks).

#### JULY, AUGUST, SEPTEMBER

During these months work was limited mainly to feeding (.2 lbs per duck, 2x each day), watering, mushroom soaking and harvesting, and observations. Three randomly selected ducks from each breed were captured once per week and weighed. We learned many things about duck behavior and the

differences in breeds, noted in the previous sections of this publication.

#### OCTOBER

The ducks were taken to a local slaughterhouse on October 16. We stretched the kill date this long to see if there was any benefit to weight gain – or if weights would level off. Ducks were all sold to a local restaurant, which also hosted the tasting event.

#### NOVEMBER

The tasting event occurred November 6th. We had 16 participants including chefs, farmers, Extension associates, and consumers. Each breed was minimally prepared and served in a blind test in two rounds; round one was breast meat (light meat), round two was leg (dark meat).

Participants tasted the varieties and made notes on a worksheet provided. The most surprising element agreed to by all was that there was such a difference in taste between breeds. The Pekin (donated from a local farm) was the consistent favorite, while the Muscovy received poor marks and the three heritage breeds (Rouen, Blue, Cayuga) had positive marks with many participants noting more interesting flavors, in comparison to the Pekin which was deemed a "safe eat" for general consumers.



## YEAR TWO - 2013

For the second year, our trials were simplified and several changes occurred. First the size of the paddocks were reduced and restricted to areas right around mushroom fruiting zones rather than integrated directly in the fruiting area. The ducks were rotated from forest to field to diversify their diet as well are reduce the impacts from continuously grazing the woods.

Based on the previous year, we decided to raise two flocks of 25 ducks each; one Rouen and one Cayuga. The flocks were ordered as a "straight run", meaning a mixture of male and female. The biggest change overall was that grain inputs were limited and offered at a lower rate while trying to maintain weight gain (.2 lbs per bird/day, which is HALF of the previous year)

We again received ducklings in the mail (April 22), raised them in the metal stock tank brooders, and then transitioned them to pasture on May 20 and forest on June 16 (this is when the rationed feed began). Duck houses were rebuilt to be smaller than in 2012 and more easily movable. The ducks were moved once a week from field to forest or vice versa. Each of the three mushroom yards got a different treatment; one was a control (no ducks), one had ducks constantly in and around the mushrooms, and one had ducks visit only twice throughout the season.

The results were suggestive at best, at least in terms of slug control (see more below). One variable was that slugs actually didn't show up in prolific numbers unless the conditions were rainy, or at least moist. It turned out to be hard to collect reliable slug damage data, but from general observations the mushrooms harvested from the logs that were protected by the ducks were in significantly better condition than those not near the ducks.

TIMELINE	FOR	2013	SEASON	

22-Apr	Chicks arrived
20-May	Ducklings moved to pasture
16-Jun	Ducks begin rotating – first visit to woods
17-Jun	Food rations begin (.2lb/bird/day)
10-Oct	Ducks Slaughtered

A discovery made in both 2012 and 2013 is that some ducks will make an effort to eat, or at least nibble at, the mushrooms. This was observed in the Muscovy/Rouen flock of year one and in the Cayugas in year two. This means that to maintain a good crop, fruiting mushrooms need to be fenced off from the ducks. This is acceptable because the ducks can be rotated around this enclosure to reduce slug pressure, rather than eating the slugs right off the logs. Fencing off the mushroom also eliminates any concerns with sanitation of manure and associated concerns with food safety.

In 2013, about ½ of the ducks were slaughtered on October 10 and sold to a local meat butcher, who sold them to consumers almost immediately, as well as to a local restaurant. Of the other half, some were traded to a neighbor for labor and we kept 12 of the Cayuga (10 female, 2 male), merging them with out Khaki Campbell flock (not part of the study) to establish our long term laying flock.

#### **FINAL RESULTS**

We achieved many good results, some based on observation and some on data. The first result is that ducks provide a significant level of pest control throughout the farm (including forests, fields, and gardens) and, if rotated, do not appear to have adverse effects on the landscape.

Of the ducks we raised for meat, only the Muscovy gains sufficient weight to make a profit and a duck would need to gain at least 8 lbs in a season to make it economical under our model. Given feed costs and market prices, and depending on a farmers slaughtering capacity, a range of 150 - 400 ducks would need to be raised per season to be economically viable.

Bringing the ducks into contact with the mushrooms did appear to have a positive effect on reducing slug populations, though the mix of variables (weather, temperatures, labor, etc) made it difficult to collect good data on this relationship.

We will offer our final results including our summary observations and any relevant data by revisiting each of the three main questions this study sought to answer.

#### 1. Are ducks effective and reliable slug control in log-grown mushroom cultivation?

From this study, we were unable to collect conclusive data on if ducks offer a viable means to reduce slug infestation on shiitake mushrooms because of variables and unpredictability in weather, precipitation and temperature. However, our observations did lead us to believe that the presence of ducks in the vicinity of fruiting mushroom logs can help but not entirely eliminate slug pressure on a shiitake crop. Ducks are not the perfect solution, but rather a supplement to other strategies including the removal or organic matter from the fruiting area, placement of gravel under logs, use of beer traps, and daily monitoring.

In 2012, the drought conditions meant the mushroom yard had very low slug pressure. We saw some slugs toward the end of the summer and at the same time observed that ducks were effective at slug control IF mushroom logs are located near to duck food, water, and housing.

In this same year, we had almost 0% slug damage in the Muscovy/Rouen pen, but only after the fruiting logs were fenced off because the Muscovy would actually take large bites from the



mushroom.

The fruiting area in the Cayuga/Swedish Blue pen was probably located too far away from food/ water/shelter of the ducks and slug damage was comparable to the control. It seemed that the ducks did not spend that much time near the logs and thus did not feast on the slug population.

In 2013, we had a much wetter season and with this saw the rise and fall of slug pressure. Since we rotated the ducks weekly this season, we did not have the ducks continuously grazing near the mushroom logs. As such, we created three levels of interaction: The Control (no duck visits), Light Interaction (two visits in the season) and Heavy Interaction (ducks constantly in or near mushroom yard). The Control yard most certainly had the most slug activity. The Light area had ~ 50% less observed slug activity, and The Heavy area had very little slug activity.

As we suspected, and now observed, slug populations directly relate to moisture/weather. A further fact is that, since slugs are blind, they find the mushrooms by smell as they open up and release spores. Removing slugs from the general area when mushrooms were pinning proved

to be helpful. If precipitation patterns are timed with soaking mushroom logs, and subsequently mushroom fruiting, high slug pressure may be avoidable, but certainly it will vary from year to year depending on weather. Though we are just starting to test this out in our system, these cycles and timings may important for the shiitake grower to take note of in order to lessen overall slug damage on fruiting mushrooms.

A final key point is that the presence of ducks in the woods does two things: first, it decreases organic matter which is ideal habitat for slugs, and two, it directly reduces the ability of the population to both move in toward the mushrooms as well as build up a population. In conclusion from our observations, it did not appear to be important to have ducks in a particular place at a particular time. If they can be rotated around the area that the mushrooms are produced, there will likely be some benefit for the farmer.

#### DATA/DOCUMENTATION

We had a difficult time collecting good data to support our observations for a number of reasons. In 2012 we tried to calculate the percent of damaged mushroom caps vs. perfect caps in the three laying yards, but found that this assessment is subjective and that, since there are other causes of damage (weather, rodents, farmer, transport), it was hard to ensure that damage was from slugs and not other factors.

In 2013 we attempted to switch our collection methods and tried collecting and weighing the slugs that were found in the general vicinity of the log fruiting rack. This proved to be challenging, as it took an incredible amount of time and just because a slug is in the mushroom laying yard does not mean that slug will damage a mushroom cap.

Further, on several occasions, even a day after a sweep of the area, the slugs were present on the mushrooms and would take constant monitoring of the yard to be effective. Balancing the need for monitoring with the realities of farming (not to mention that picking up slugs one by one and weighing them is rather disgusting), we did not continue trying this method for too long. For future studies, a consistent set of slug traps to gain an effective count would likely be a better approach for achieving a better dataset.

All this being said, there were two definitive indicators that offer evidence to support that foraging ducks near a mushroom laying and fruiting yard is worthwhile to control slug pressure:

#### 1. Average slugs/log

On two occasions in 2013 we were able to sample ten logs from each laying yard and count and average the slugs/per log for each area. This was done during a wet period when overall slug activity was high and when timing allowed for this to work. While this isn't enough data for anything conclusive, it does offer some suggestive evidence of some benefit.

Date	Yard 1 (control)	Yard 2 (light)	Yard 3 (heavy)
6/27	12.3	9.8	3.1
7/13	10.1	8.4	2.7

Average slugs per log for two random dates in 2013

#### 2. No mating pairs

One positive outcome of the study was that no mating slugs were found in the mushroom area with ducks heavily grazing around versus many dozens found during wetter parts of the growing season in the control area and a few in the light area. This was a constant observation made on a weekly basis throughout the season. While this doesn't directly relate to damage, the ability of a population to reproduce is arguably one indicator of overall population success.

#### 2. Is the forest affected in any negative way from the presence of ducks?

The presence of ducks in the forest has one critical impact observed; leaf litter from the previous fall decomposes much more quickly when animals are in the forest. In some areas of the woods, particularly where water pooled and flowed during heavy rain events, grazing appeared to create bare ground and mild compaction, which led to some minor erosion. This impact was much more dramatic in year one when the stocking rates were high (50 ducks continuously in a 1/3 acre paddock) versus year two, where smaller flocks of 25 were rotated in smaller, ¼ acre paddocks.

One good strategy to balance the trampling of organic matter was to time the cleaning out of the duck houses so that the straw and manure accumulated was removed just before the ducks were moved to a new location. It is recommended that additional organic matter is available to be added to a forest grazing system. In the future we plan to monitor nutrient content and percent organic matter in our soils to get a better grasp on potential benefits or harm from grazing animals.

In 2012, we let the ducks forage in one area continuously. As a result, there was noticeably less forest litter and in some case bare ground due to the movement of the duck flocks. In the Muscovy/Rouen pen this was especially the case. In this regard, continuous duck presence had a negative effect on forest health. As a result, and to keep more inline with our farm goals, in 2013 ducks were rotated weekly between different plots in the pasture and the forest.

#### 3. Are ducks economically viable as an additional income stream?

The simple answer to this question from our experience is "yes", if a farmer is willing to greatly scale up flock size and if producing the product is the primary focus of the activity. (not slug control).

In the context of a small woods (about 1 acre) and a 1,000 log shiitake operation, a flock of 20 to 25 ducks is plenty to maintain some degree of protection from slugs, including some time rotat-

ing in gardens and fields, too. We are maintaining this size flock and selling eggs, with the simple goal of covering our feed costs and eating eggs we produce.

To be an economically viable duck meat farmer production would need to be a primary goal, not a byproduct of a desire to control slugs and enhance an ecosystem. The good news for those interested is that the market demand is very high (at least in our region). It should be noted that we sold to restaurants and a retailer who cater to custom-



ers in a market of customers willing to pay more decent prices (5 - 6/lb) for sustainably raised and local meats.

In 2012, the chef at the restaurant we sold our birds to was happy with the product and sold out of them within two days on the menu. There is clearly a demand in this market. This restaurant, as well as several others, told us they wanted more duck and have a hard time finding it. With regards to specific breeds, this particular place (a small restaurant in rural New York, with 50 seats, serving as much local food as possible for \$15-30/plate) felt the Muscovy were a bit too big and preferred the birds that were 4 - 5 pounds with a more interesting flavor. Specifically, their ideal choice would be the taste of the heritage birds, and just a little bigger.

It is challenging to quantify the value of fertilizer the ducks provide to the system, along with the benefits of slug control. We are finding that the ducks are proving valuable not only in the woods, but in our gardens and around planted tree crops as well. In 2013, our garden saw little to no slug and bug damage to plants, and the



ducks also performed well when given access to cover crops we had sown as part of a soil building protocol. It is also our observation that the Khaki Campbell and Cayuga's, are better foragers and less interested in grain than the breeds more ideal for meat production.

#### DATA/DOCUMENTATION

#### Weight Trends

DATE	N	uscov	Y	Avg	ROUEN		Avg	SWEDISH BLUE		Avg CAYUGA		4	Avg			
21-Jun	4.44	4.60	4.53	4.52	3.76	4.10	4.22	4.03	4.31	4.26	4.31	4.29	4.20	3.91	3.75	3.95
4-Jul	6.65	6.78	6.42	6.62	5.69	4.82	5.02	5.18	4.98	5.29	5.44	5.24	5.19	5.32	4.75	5.09
11-Jul	7.41	6.50	7.10	7.00	4.80	4.70	5.00	4.83	4.30	5.35	4.80	4.82	4.66	4.68	4.81	4.72
18-Jul	8.90	8.40	9.00	8.77	5.60	6.50	5.70	5.93	4.60	4.80	5.20	4.87	5.40	5.50	4.60	5.17
26-Jul	8.19	8.79	8.60	8.53	5.75	5.45	5.68	5.63	4.71	4.91	4.91	4.84	5.05	4.72	5.46	5.08
1-Aug	9.18	9.18	10.36	9.57	5.62	5.24	5.65	5.50	5.77	5.51	5.07	5.45	5.82	5.71	5.56	5.70
10-Aug	9.93	10.04	10.64	10.20	5.54	5.33	5.86	5.58	4.61	4.24	4.63	4.49	4.67	5.12	4.69	4.83
16-Aug	8.86	11.10	10.40	10.12	5.49	4.90	6.02	5.47	5.10	4.84	5.09	5.01	5.43	4.91	4.88	5.07
29-Aug	10.33	11.47	10.28	10.69	4.68	4.83	4.78	4.76	5.42	5.11	4.75	5.09	5.56	5.08	5.48	5.37
6-Sep	12.08	9.79	12.02	11.30	5.08	5.21	4.69	4.99	4.77	4.44	5.08	4.76	4.16	5.38	5.50	5.01
13-Sep	9.50	11.20	9.40	10.03	4.73	5.28	4.44	4.82	5.10	5.14	5.65	5.30	5.81	5.51	5.25	5.52
21-Sep	10.37	11.99	11.28	11.21	4.35	5.68	5.14	5.06	5.52	5.00	5.03	5.18	5.45	4.97	4.94	5.12
2-Oct	12.83	12.21	12.90	12.65	4.81	4.68	5.02	4.84	5.00	4.86	4.94	4.93	6.01	5.02	4.73	5.25

We can examine trends in weight gain from the ducks. In 2012 we randomly weighed three ducks once/week from late June through early October. The entire dataset and averages per week are presented below.

Notable is that there is a decent amount of variation among the duck weights from week to week. The Muscovy is the only breed that had solid growth over the course of the season. Most of the other breeds could arguably be slaughtered much earlier in the season since they appeared to

reach average max weight in August.

Important to note in this trial is one aspect of a poor experimental design, where the Rouen/ Muscovy were lumped as were the Swedish Blue/Cayuga. While the latter group appeared to share their food and finish throughout the day, the Muscovy dominated the Rouen flock and ate far more than their fair share. Either way, it is clear that if weight gain is a clear goal for commercial meat production, then Muscovy is the choice from these breeds.



#### Feed Costs

A second metric with consideration for meat production is feed cost, since it impacts potential profit. Our strategy was to feed the ducks "free choice" for the first eight weeks of their life and then transition to a ration, based on the recommendations of books. In 2012 we provided a maximum amount of .2 lbs/bird twice each day (.4/lb/bird total) and did not rotate their pens, whereas in 2013 we cut that amount by 50%, feeding only once a day at a rate of .2lbs/bird though rotated them weekly.

Based on the number of ducks, we calculated the cost of feed per day for the first eight weeks and then did another calculation for the remaining time until slaughter. Since the rationed feed was cut in half the second year, the cost per bird is roughly half from one year to the next.

Year	Number of ducks	Days Free Choice (\$.3.05/ day)	Total Cost	Days with Rations (\$6.24/ day for 2012, \$3.12 in 2013)	Total Cost of Rations	TOTAL COST	Cost per bird
2012	50	53	\$161.65	129	\$804.96	\$966.61	\$19.33
2013	50	56	\$170.80	117	\$364.04	\$534.84	\$10.70

The interesting analysis comes when we looked at the potential profits based on the weight gain and price per pound we got. For this we removed the Muscovy ducks from the dataset because we did not have them in the second year, and all the other ducks were in a similar weight class. This worked well because it made the number of ducks in the sample size equal, since we did not harvest all 50 the second year.

#### **Potential Profit for Medium Weigh Breeds**

Sample Size	Cost per bird	Avg Weight Per bird	Price per lb	Avg Gross Per bird	Profit/Loss
30	\$19.33	3.49	\$5.50	\$19.19	14
30	\$10.50	3.31	\$5.50	\$16.55	\$7.70

#### **Potential Profit for Muscovy**

Sample Size	Cost per bird	Avg Weight Per bird	Price per lb	Avg Gross Per bird	Profit/Loss
30	\$19.33	8.14	\$5.50	\$19.19	\$25.44

We were pleased to see that cutting the feed in half and rotating the ducks weekly led to only a very small decline in average weight per bird. This may not be the case for the larger meat breeds but we can say for certain that for Cayuga and Rouen, more feed did not contribute to more weight gain, and in fact resulted in a net profit, at least when only feed is taken into consideration.

The \$6.05 in profit is just taking into account feed costs. When we consider other costs, the potential looks less optimistic. For one, in both seasons we took the ducks to a certified facility, as we lacked the space and infrastructure to slaughter on farm properly. Furthermore, to sell to the

outlets we chose (in 2012 a restaurant and in 2013 a butcher shop), New York State law requires that we process at such a facility. It cost \$4/duck to slaughter and package, which means that we have a further loss in potential profit per bird in 2012 and reduce our potential profit to \$3.70/bird. Furthermore, we also have to subtract the cost of a duckling from this number, which was \$5 per bird. In the end, considering the costs of feed, slaughtering, and ducklings, a total potential profit in 2012 was \$1.30/bird for the medium weight breeds and \$21.44 for the Muscovy.

One point of good news for those interested in ducks for meat is that the heritage birds appear to gain their maximum weight early in the season and then level off. This mean that smaller breeds could be raised on shorter rotations, which may improve their profitability since feed costs, time and labor would all be less. We found that a 3 – 4 pound duck (finished weight) was acceptable to some customers and though not very large, very delicious and can provide a sizeable meal to two people. The breasts and legs from one bird are a good serving size for two people, with the carcass making a fine stock. If a farmer can find markets willing to purchase smaller heritage birds, she/he may be able to find a profitable niche.

#### **Other Costs: Infrastructure**

Of course, feed and slaughter costs were not the only costs. Over the two years we spent a considerable amount of money on the facilities to house, feed, and provide water to our duck. Certainly many of these expenses are capital requirements that are beneficial for the long-term and not recurring annually. In this case \$2,950.29 of materials and supplies can be spread out over say, ten years, or \$295.29 per year. To cover feed costs (above) and break even on infrastructure costs, a farmer would need to raise about 15 Muscovy ducks per year for ten years. Of course, if we raised around 150, then we could pay this infrastructure off in a season, and begin making profits in the second year. This is a viable and realistic option for meat production; however, these numbers do not take into consideration time/labor.

	Actual
Movable Electric Fence	\$866.00
Fence Charger	\$227.50
Fonts, tubs, feeders	\$71.45
Duck House Materials	\$688.08
Water Pump	\$399.00
Water System	\$698.26
TOTAL	\$2,950.29

#### Labor

The above figures do not include accounting for our time. We consistently spent an average of 30 minutes a day on chores, which equals 64 hours in 2012 and 58.5 in 2013. Add another 40 total hours on building, repairs, etc. This is a total of 100 hours of labor. At \$12/hour, this is another \$1200 to the total cost. This means that raising Muscovy ducks for meat, a farmer would need to add another 60 ducks per season to break even.

#### **Financial Summary**

The total costs to raise ducks for meat appear to be approximately:

\$20 per bird for feed (for meat breeds that gain sufficient weight)\$5 per bird for duckling\$4 per bird for slaughter

\$3000 in start-up costs (\$300/year) \$1200/year in labor

If an 8-pound bird can be sold for \$40 (\$5/lb), then 150 birds would allow for a break-even including labor over ten years, while raising 420 birds would pay off the costs in a single season. The calculations we have provided are based off 50 birds, and relatively minimal numbers with regard to labor, material, etc.

Unfortunately, this is a reality with many small farm operations. We are aware of this challenge and it remains one of the reasons we stack the duck chores with mushroom cultivation – where we get two yields for my time.

#### **Reducing Costs**

There are many ways that costs could have been reduced, which might make this scenario more reasonable for a farmer considering the potential for meat production. They include:

- 1. Purchasing feed in bulk. This would require an upgrade of storage facilities but could probably pay off in a ten-year timeframe. Since we were trialing the concept we didn't invest in such a unit.
- 2. Being more careful on infrastructure purchases. Some of the items in the chart above turned out to be less ideal in the system and could have been reduced or avoided. This included some of the fonts, feeders, and troughs. We recommend the necessary infrastructure in the previous sections.
- **3.** Raising meat breeds with good weight gain. Remember that the first potential profit calculations above were done with the medium weight birds and that the Muscovy fared much better. The medium weight breeds are simply not appropriate for meat production in the current market, though they might be able to be successful in a local niche market where customers are willing to work with smaller birds.
- **4. Raise your own ducklings.** More analysis would need to be done on the costs of infrastructure, but since purchasing ducklings from a hatchery runs roughly \$5 per duckling this could be a big money saver.

## CONCLUSIONS

Out of all the lessons we learned through this project, the most valuable result was considering how this system affected our farm goals and values.

One of the primary goals on our farm is to continuously try to reduce outside inputs, especially grain feed, as it is energy intensive and cost increases. One of the initial appeals of ducks was the idea that they could forage much of their food needs on the farm. What we did not consider was that raising poultry for meat inherently means relying on some grain, as there is pressure from consumers to get the birds as big as possible in as short a time as possible.

We question if raising poultry for meat markets is inherently unsustainable, especially when compared to ruminants, who can largely be fed from maintained pasture and on-farm feed (hay). Our focus is moving forward is to examine the potential to produce eggs and see if we can maximize onsite food production. Our focus for meat production, at least commercially, is shifting to sheep, which we think we can raise with less outside inputs as compared to any poultry.

Our idea to integrate ducks into other farm systems appears to be a good road to head down, but we recognize that ducks are but a mere part of the whole system. It was perhaps too optimistic hope that adding ducks to a dynamic forest ecosystem would rid us of our slug problems. This project reminded us that we cannot expect that one species or strategy will solve a single problem entirely. This is not how nature operates. Instead, ducks have proven to be part of the solution, one that we will continue to explore over the many seasons ahead.

We also learned that research is challenging to do when one is also farming a crop or system. The time and discipline required to capture all the data we may have wanted to just wasn't always available. This is often why farmers are making decisions on the fly, and more often based

on observation or instinct rather than numbers and statistics. Yet, we have recognized through this project the incredible importance in data collection. It's most important benefit is that it aids in our decision-making. Without measuring feed and calculating costs, how would we ever know if were we even close to making a profit, much less breaking even? While there are endless possibilities as to the types of data one could collect, we are keeping a keen eye to those which would be worth it; especially feed costs and the effect of rotation and a larger diversity of forages on animal health and weight gain.



The opportunity provided by the funding to step into a new venture without the pressure of economics was critical in our ability to collect information, reflect on our experience, and learn a great amount about the potential of integrated systems. We are pleased that ducks will continue to rotate through our forest and fields, offering a worthwhile service, providing us with product, and enjoying a healthy existence all at the same time.

## Project 2:

## Decreasing small ruminant exposure to parasites by reducing slug and snail populations through a sheep/duck grazing system

#### **SUMMARY**

This project aimed to explore the potential benefits of multi-species grazing of sheep with ducks in order to address the parasite Parelaphostrongylus tenuis (P. tenuis, a.k.a brain worm/deer worm). This parasite is transmitted to sheep through deer and then slugs/snails before affecting sheep. Infection often leads to paralysis and death of the affected sheep. In the past, we've demonstrated that ducks can reduce slug populations that are a pest to shiitake mushroom production (Project FNE12-745).

In order to monitor slug populations in 2017, we distributed traps made from soda bottles in 10 locations in each paddock, roughly 50 feet apart. We filled the trap with about 1 - 2" of fresh beer. We monitored traps twice each week in 2017 ad 2018, counting slugs captured and also emptying and refilling with fresh beer, an important practice to ensure the traps would continue to attract slugs. A basic count of the total slugs was taken per paddock and recorded. We tracked these figures from June 19 through October 13 a total of about 17 weeks of study. We also looked at variables including precipitation and grass height. We were able to acheive some notable affect of grazing ducks on slug populations.

We have concluded that while some short-term impact/benefit can occur on slug populations from duck grazing activity, it may not be enough to justify the labor and time to monitor populations, coordinate moving them into the right place at the right time, all with special effort just to realize a benefit on reducing parasites.

In other words, if you are in a situation where you have ducks and are rotating them, you might receive some secondary benefits of running them through pasture, but its not worth going out of your way. This conclusion is not due to the fact that ducks aren't inherently effective at reducing slug populations. It's more about the challenges of varying dynamics, timing, and labor that make the prospect challenging.



#### INTRODUCTION

This project builds off our previous research (FNE12-745) where we determined best practices for utilizing ducks to control slugs in our log-grown shiitake enterprise. We are mostly interested in having ducks on the farm for this pest control benefit, but have also found a modest income from egg sales.

Our success with ducks in the mushroom enterprise and anecdotally in our gardens and orchard systems has led us to see their benefit to many systems. Moving them into the sheep rotation may be beneficial, but there is likely an issue with getting the proper timing down to have efficacy. Our main question; is it worth rotating the ducks in sheep paddocks to reduce the slug population and thereby reducing our sheep flock's exposure to parasites?

Big thanks to Jonathan, Shaun, Claire, Cat, Carly, and Chad, our on-farm helpers in 2017 and 2018, who were awesome and stayed positive even while counting slugs!

#### Our goals for the project are to:

- **Objective 1:** Determine if grazing 50 ducks reduces gastropod populations in half acre paddocks
- **Objective 2:** Reduce brain worm parasite risk to grazing ruminants, thereby reducing the need for Ivomec, dexamethasone, and Safeguard
- **Objective 3:** Determine ideal timing of leader-follower rotation that results in low gastropod population, minimal duck poop presence on pasture, and diverse and abundant forage



The focus of this project sought to draw out the potential benefits of having animals on a landscape that, while not turning a huge profit, contribute to supporting the profitability of other more lucrative enterprises. In this case, our log-grown shiitake and pastured sheep enterprises are the most profitable systems on the farm, while ducks are a harder prospect from a profit standpoint.

The cost of production for eggs, along with consumers expecting eggs to be cheap, means that there are very thin margins in egg production. Our goal has been to sell eggs in order to cover the cost of raising the ducks – from an inputs and labor standpoint. We could therefore benefit from the ecosystems services the ducks provide, produce our own eggs for consumption, and not have to pay for it.

To us, this is an important aspect of modern US farms. In recent times, the focus for farm production has been almost exclusively for market production, which means certain systems get left out of the business, whether they provide benefits or not. It wasn't so long ago that most family farms in the US balanced production for home, family, and community at a small scale with an additional selection of "cash crops" to provide money to the farm. We have found high value in mixing systems that produce goods at a smaller scale and fit well as a complement to those we focus more on a cash return. The ducks, our orchards, and vegetable production all fit into this "homestead" category, while we produce mushrooms, pastured lamb, maple syrup, and elderberry more for commercial markets.

#### **MATERIALS AND METHODS:**

Due to the historic D3 drought in our region during the 2016 grazing season, we opted to delay the start of monitoring slug populations to the 2017 and 2018 seasons. Our past experience meant we knew the work would produce less than valuable results, because slug populations are virtually non-existent during dry times. Additionally, the drought conditions meant that pasture did not grow after the sheep's first rotation in May. We spent 2016 reorganizing our grazing system to accommodate drought and make use of hedgerows, which will help tremendously as we set out to collect



Figure 1.1: Map of Trap Sites

data over the next two seasons.

We realized as we planned for the 2017 season that starting to rotate ducks into paddocks would not be useful without first establishing baseline data for each paddock, since it cannot be assumed that slug populations are the same for each location, nor do they stay consistent with the seasonal changes in weather patterns.

If we stated integrating ducks right away, we might observe differences in control vs. treatment paddocks that we would attribute to duck activity, when the variability may in fact be due to other factors. The main factors we believe affect the presence of slugs in paddocks include 1) recent weather, especially precipitation, 2) length of the grass, 3) previous impacts on slug populations.



Figure 1.2: Slug Trap

Therefore, we decided that in 2017 we would collect slug population data and track our sheep grazing, as we might normally do. We could then look and see if there are any trends in slug populations, any differences among paddocks, and any correlation with weather events.

In order to monitor slug populations in 2017, we distributed traps made from soda bottles (see figure 1.1) in 10 locations in each paddock, roughly 50 feet apart. Each trap was sunk into the ground using a bulb digging tool and set so that the opening of the trap sits at ground level. We filled the trap with about 1 - 2'' of fresh beer.

The map (see figure 1.2) of these trap shows we aimed for a relatively even distribution of traps, though there is some variability in the shape of the paddock. We selected the paddocks in the wettest locations closest to the woods edge, as we assume these are more likely to have slugs (intermediate host) and also deer visiting the pasture, who are the origin host for the parasite in question. We monitored traps twice each week in 2017 ad 2018, counting slugs captured and also emptying and refilling with fresh beer, an important practice to ensure the traps would continue to attract slugs. A basic count of the total slugs was taken per paddock and recorded. We tracked these figures from June 19 through October 13 a total of about 17 weeks of study.

#### **RESULTS AND DISCUSSION:**

As the graph below shows for the year 2017, results of the data collected indicate there will be some consistency to the pattern of slug presence among the collection of paddocks selected for this study. This is useful as we attempt to add ducks to 3 of the paddocks in 2018, to see if we can affect populations. If successful, those paddocks would hopefully deviate from the overall trends.



When comparing this graph to local precipitation data for the same timeframe, there is not a clear correlation between anything happening with precipitation and a "response" from slug populations:



We are ready to proceed to the treatment portion of the research in 2018, and will better track grazing in the paddocks, as well as grass height, as we are curious if this has any effect on slug presence. We will accomplish this by measuring the average height as we take slug counts. Our theory is that less grass = more drying out, which could have an effect.

#### 2018 RESULTS

For the second year, the goal was to track the changing dynamics of slug populations in the same paddocks, as well as attempt to implement the "treatments" – that is, a roughly week long residency of the ducks in 3 our of the 6 paddocks, to see if there was any impact they offered to reduce slug populations. While as previously mentioned we delayed the start of this projects in 2016 because of historic drought, 2018 was notably wet, after a normal/dry May and June.

The months of July, August, and September each were 2 - 3 inches more rainfall than normal (almost double the amount) and for the year we are 10 - 15 inches over normal rainfall. This is im-

portant to mention from the outset, as the rain likely affected our data, since excessive rainfall was found to flood the traps on several occasions, which dilutes the beer and effectively suppresses the yeasts that attract the slugs.

That said, our overall slug counts were reasonably aligned with those of 2017, at least in terms of showing the high variability and change that naturally occurs in slug populations, as shown in the graph of counts for the 2018 season:



There are two notable patterns when comparing both years that are useful. One is that in both seasons, the highest slug counts were in the spring, though we started counting in late June in 2017, and mid May in 2018. Regardless, in both seasons, the relatively high counts dropped below 100 per paddock by early July, and never returned to the spring and early summertime high points.

The other relevant pattern is that... there isn't really a consistent pattern. Rates are not consistent or constant, but rather ebb and flow. As noted in 2017, rainfall wasn't a reliable indicator of these dynamics, and in 2018 we looked at grass height, where we also found that the height of the grass didn't prove to be a helpful indicator of slug levels, either, as noted from a few sample paddock data sets. For some paddocks, we even intentionally let the grass grow very high (see paddock 3) to see if there was any effect – and there was no clear correlation.

While we had hoped to do two visits of the ducks to each of the three treatment paddocks (for six total treatments), because of the heavy rainfall and persistently wet soils, we were only able to do one set (three treatments). Our duck house, small tractor, slopes, and mucky soils led to many issues early in the season.



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Before doing a treatment, we were also looking for a data set with a good high number of slugs in each paddock, because we figured if one or two paddocks had a low reading, it would be hard to see any dramatic effect the ducks might have. In retrospect, we missed our best window of opportunity in May, when counts were very high. We then had a lot of variability in June through mid July, and finally decided to just give it a try when we took our 7/24/18 readings and saw some reasonably high numbers across the board (in light orange below):

	Date	Plot 1	Plot 2	Plot 3	Plot 4	Plot 5	Plot 6
	5/18/18	165	205	231	50	47	52
	5/25/18	88	149	100	50	38	65
	6/1/18	82	174	61	42	20	22
	6/8/18	76	49	89	27	26	7
	6/26/18	64	104	91	23	35	75
	6/29/18	5	29	35	16	6	11
	7/3/18	12	7	16	11	7	3
	7/6/18	34	7	16	27	10	11
	7/13/18	32	33	29	32	29	43
	7/20/18	10	33	31	32	17	12
	7/24/18	53	96	93	66	27	13
	7/31/18	9	39	44	28	30	26
	8/3/18	9	22	44	24	11	13
	8/7/18	10	10	6	55	49	46
	8/10/18	37	50	5	65	72	72
	8/15/18	57	60	4	70	55	48
	8/17/18	23	41	4	5	12	10
	8/21/18	26	23	15	3	21	14
	8/24/18	8	11	10	15	20	14
	8/28/18	9	7	15	13	33	33
	8/31/18	0	5	2	8	7	11
	9/7/18	3	12	19	12	29	22
	9/14/18	15	17	9	33	45	32
DUCKS IN		7/30/18		8/6/18	8/14/18		
DUCKS OUT		8/6/18		8/13/18	8/21/18		

The yellow blocks indicate samples that took place during the residency of the ducks in one of the treatment paddocks (1, 3, or 4). Each paddock was randomly selected from the entire sample group as the treatment areas. We attempted to sample as consistently as possible on a weekly basis, sometimes taking an additional sampling point during the season because of the rain affecting the viability of the slug traps. Perhaps the biggest takeaway from this project is how hard it is to track slug population dynamics, given all the variables at play.

During the treatment weeks, our ducks were brought in and kept in the space for approximately one week. If we zoom into this period of time and compare the results between the control paddocks and the treatment, one interesting pattern emerged:



Slug Control Paddocks

While the plots above show the characteristic rise and fall we see as a large pattern, the treatment paddocks had a noticeable flatlining of the counts during the residency period, though for widely differing durations. The flat line persisted in paddock 1 for seven days, versus ten days in paddock 3, and just four days in paddock 4. The arrows indicate how long the ducks were in each paddock:



Notable also is that in all cases, slug levels were already in decline for each treatment before the ducks arrived. But when we compare to the larger picture of all paddocks, we do see some indication of effect. With the first treatment (blue), all other paddocks rose, while paddock 1 stayed flat for a longer period. For the second treatment (gray), all other paddocks were on a sharp upward trend, while paddock 3 remained low. For the third treatment (yellow), all paddocks were on the decline, but started to rise again, whereas paddock 4 lagged a bit further behind:



Important to note is that while some effect was seen above from duck activity, it was not particularly long lasting. In all three cases, in just a few days after the ducks left the paddock, the slug numbers generally rejoined the overall pattern of population dynamics across all of the paddocks.

Since the pastures also clearly needed some rest and recovery time post-duck before sheep could graze, this approach doesn't seem to be particularity effective when taking in the larger context of our goal, which was to reduce exposure of our sheep to parasites. We found that a paddock needed 7 – 10 days of rest before the pasture was just grazeable, and thus by the time the sheep arrived there would be little benefit of any substantial reduction in slugs.

Given this result, and the amount of labor it took to monitor slug population dynamics, and the high variability within the 10 traps in each paddock, there is a larger question about the practicality of this on a farmer level.

Even if we could replicate this trial and get better results, could farmers easily decide if and when to put ducks into a rotation in a way that might offer clear benefits to their grazing animals? Since weather, precipitation, grass height, and overall slug population dynamics act independently of each other, there seems to be little benefit in attempting to utilize ducks in this way. Knowing there IS benefit to the presence of ducks, however, is useful. We just don't see a way to plan or control the affect in a way that is time effective.

Its notable that in two seasons, the population of slugs were significantly higher in the spring and early summer months. Also important is that for both seasons, the really high numbers were in paddocks 1, 2, and 3, which are situated lower in our landscape, border a creek, and often have wetter soils that take longer to dry out. Paddocks 4, 5, and 6 were higher in the landscape and dried out sooner. So, there may be benefit of putting ducks through the pasture in early Spring to reduce the overall slug populations, which could reduce their ability to reproduce. This is the general approach we concluded from our last grant, where we more effectively utilized ducks to control slugs in our woodland shiitake mushroom operation (https://projects.sare.org/sare\_project/fne12-745/). The major difference is that its easy visually to see the effect of ducks clearing out slugs on our mush-room crop, but harder to measure the efficacy in pasture, since its literally harder to see the slugs, as well as monitor any effects on the "crop"- i.e. if the sheep are ingesting them (versus the slug damage visible with the mushrooms).

#### **RESEARCH CONCLUSIONS**

We have concluded that while some short-term impact/benefit can occur on slug populations from duck grazing activity, it may not be enough to justify the labor and time to monitor populations, coordinate moving them into the right place at the right time, all with special effort just to realize a benefit on reducing parasites.

In other words, if you are in a situation where you have ducks and are rotating them, you might receive some secondary benefits of running them through pasture, but its not worth going out of your way. This conclusion is not due to the fact that ducks aren't inherently effective at reducing slug

populations. It's more about the challenges of varying dynamics, timing, and labor that make the prospect challenging.

This project demonstrates the reality of trying to solve an on-farm problem by managing a complex ecological dynamic. At the end of the day, this idea would just be one more way to reduce parasite impact on our grazing sheep, along with breeding and selection practices to



favor resistance, and the inclusion of high-tannin forages in their diet to reduce the effects of parasite build up. We are proceeding in this multi-faceted approach, and will target duck activity in our wettest pastures, and especially in early spring time.

To revisit our original objectives one and two, we sought to assess if ducks could reduce slug populations meaningfully in a rotational grazing system. We found that, while we can potentially reduce a population in a given paddock, the effect is not one that lasts, and is therefore impractical as a meaningful activity to attempt.

As with any research project, more years and subsequent trials could further improve on the methods and attempt more treatments, which could offer better results. Its very time consuming to measure and refill traps on a more than weekly basis; and it was impossible to do every 2 - 3 days as would be ideal, given that the beer wears out.

Should we have found that ducks were effective, objective three was then to figure out a feasible leader-follower rotation for ducks and sheep. Since the duration of any effect is so short, this objective was not able to be met, since we'd need a longer recovery of the forages before getting the sheep on them, when slug populations would potentially be back to more "normal" levels.

In summary, we can suggest a few important points and lessons learned that we think other farmers can benefit from:

- 1. Slug population dynamics are highly variable, and cannot be predicted using the month of the year, precipitation, or height of grass in a paddock. They rise and fall throughout the season dramatically.
- 2. In springtime and early summer, slug populations may be significantly higher than during the rest of the growing season, which potentially increases grazing ruminant exposure. Avoid the wettest grazing sites in early spring. Consider this as a place to target with ducks if it's easy to do without extra effort.
- 3. Monitoring for slug population dynamics is difficult, and not a feasible task for most farms to undertake in a way that will provide clear directives for action.
- 4. Ducks DO reduce slug populations but likely not for long periods of time.
- 5. A holistic approach to reducing parasite impacts on grazing animals suggests that ducks could play a role in slug control, but are not a reliable method to replace breeding for resistance, including high tannin forages in an animals diet, and other methods.

#### **PROJECT OUTCOMES**

#### Outcomes include:

- Better understanding of the complex dynamics of pest (slug) cycles in pasture
- Appreciation for the role ducks can play in reducing impact, despite the challenges from a management standpoint

As a result of the project, we will be rotating our ducks through pasture, though as part of our regular movements, and not in relation to any sort of monitoring for slug numbers. We will target their impact in the wettest pastures in early spring and summer, when slug counts appear to be highest.

We can attest after having done two grants attempting to quantify slug activity that the work is neither easy, nor enjoyable. Emptying traps and counting drowned slugs isn't enjoyable for anyone. Yet, we appreciate being able to look at the results of this consistent sampling.

As with any farming activity, weather presented an ongoing challenge. The first year we planned to sample was historically dry. The last year was historically wet. This is the reality, especially given climate change that is occurring. Yet it contradicts the desire for gathering data, in many respects.

It's also reality. We knew going into the project that ducks helped reduce slug impact, but we really wanted to see if we could come out of the project with a clear way to monitor and determine when to bring ducks in to reduce slug presence in our pasture. We were unable to acheive this, and so in some ways are back to square one; we know having ducks in pasture will offer some benefit, but we can't realistically monitor slug numbers and move ducks in any sort of ordered or measured way. It will be a bit of instinct, coupled with opportune timing. This is important as our attitude and perspective have changed. Moving forward, we will look for more ways to intentionally bring ducks into the pasture system.

## Resources

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