The Prevalence and Toll of Goat Theft in Jamaica

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Abstract

Jamaica has a reputation as a high-crime country, but it is less-widely known that one of the costliest crimes in the country is agricultural theft and the violence that often accompanies it. Theft of crops and livestock affects the vast majority of producers directly and indirectly leads to costly changes to production or protection measures to avoid theft. We argue that this suppresses growth in the agricultural sector, particularly for goat farmers. Based on a survey of goat farmers in Jamaica, this paper explores patterns in the timing and location of thefts. In our data, 60 percent of farmers had at least one animal stolen between 2016 and 2018 and the number of goats kept declined over the same period. There are strong seasonal patterns and spatial patterns of theft. First, we find that the likelihood of theft increases when there are multiple incidents of theft within the same month but with relatively few animals stolen. This is suggestive of local crime sprees. Second, when a large-scale theft of many animals from a single farmer occurs in an area, the likelihood of theft from nearby farmers decreases. This suggests that large, conspicuous events raise awareness levels and deter other thieves. Finally, the paper discusses the importance of the market for goat meat in Jamaica and the market implications of theft for farmers and retailers.

Keywords: livestock theft; crime hot spots; goat farmers

Introduction

> *I had bout 30 heads of goats and dem tek most of dem; about four lef. Mi naa bada wid it, dem thief it too hard. People only a buy goat fi cooking purpose now. One time dem use to thief a one goat; now dem a come fi the whole herd and dem a come wid gun and tell yu nuffi come out.* – Jamaican farmer (Mundle, 2018)

Agricultural theft appears to be a common and costly problem in both developed and developing countries, but it has not been widely studied in the academic literature (Barclay, 2001; Schechter, 2007; Barclay & Donnermeyer, 2011; Clack, 2013). In the United States (US), one study put the cost of agricultural crime at $1 billion USD annually, not including the cost of prevention measures (Barclay & Donnermeyer, 2011). While the role of location and farm attributes in theft figures prominently in this literature, we study the patterns in the timing of agricultural theft – both the time of year and in relation to nearby incidents of theft – using a retrospective panel data set of livestock farmers from Jamaica. This approach allows us to characterize both the types of incidents and when farmers are most at risk. This study is of particular significance due to the dearth in research on rural and agricultural crime in middle- and low-income countries (Grote & Neubacher, 2017; Donnermeyer, 2019; Clack, 2013). Given the importance of the rural economy in many low-income countries, the impact of agricultural crime can have widespread consequences and can be devastating to victimized communities (Neubacher et al., 2019; Grote & Neubacher, 2016).

Agricultural theft, or praedial larceny, is likely common around the world for several reasons. First, crops and livestock in the field are difficult to protect. The cost of effective security infrastructure is high due to the complexity of protecting mobile assets (livestock) and crops over a wide area with open ingress and egress (Bunei & Barasa, 2017; Mears, 2009; Neubacher et al. 2019). Thus, farmers may fail to invest in security and farming operations may be repeatedly targeted (Holmes & Jones, 2017). Second, where informal markets are pervasive or tracing is difficult, stolen crops and livestock can be easily sold, and, unlike other stolen goods, can often be sold at full market price. Third, in developing countries, small-scale, opportunistic theft is likely common, and sometimes even tolerated, because of poverty and food insecurity (Schechter, 2007; Fafchamps & Minten, 2009; Mears, 2009; Donnermeyer, 2014) Fourth, rural areas are hard to police (Schechter, 2007; Fafchamps & Minten, 2009). Finally, when market prices are high, this kind of theft can be extremely profitable (Barclay, 2001).

Beyond the cost of stolen property, farmers incur other costs. First, there are the direct costs of mitigation and deterrence. Examples of mitigation measures include fencing or other confinement for livestock, security cameras, and secured storage. Farmers may need to sleep in the field with their crops pre-harvest or with stored crops post-harvest, or hire someone to do so. The need for individual measures can be intensified by a lack of faith in policing and the court system (Holmes & Jones, 2017; Neubacher et al., 2019). Finally, in some areas (including Jamaica) farmers face significant risk of violence in encounters with thieves. In Madagascar, livestock theft is strongly associated with rural homicides (Fafchamps & Moser, 2003).

Second, there are many indirect costs associated with the risk of theft. Farmers may avoid certain crops or livestock, limit scale, or sell or harvest at sub-optimal times. Schecter (2007) reports that 42% of farmers in a study in Paraguay did not plant certain crops to avoid theft. Although their study is of traders not farmers, the findings of Fafchamps & Minten (2006) document the costs of avoiding theft. They find that traders avoid expanding their operations because they feel they must personally guard stocks. When farmers in Kenya were randomly assigned hired security, cases of theft decreased, conflict with neighbors decreased, and output of less vulnerable crops and off-farm work increased (Dyer, 2023). The latter result seems counter-intuitive, but this resulted from farmers being able to reallocate time away from what they perceived to be the fields most susceptible to theft. In Madagascar, the dramatic increase in global vanilla prices led to rampant theft from plantations. Farmers often harvested vanilla beans before they ripened, reducing quality. Farmers also reported an increase in anxiety and conflict (Neimark et al., 2019).

Although primarily based on studies of urban crime, there is widespread recognition of the importance of location and spatial correlation in the crime literature (Townsley, 2009; Ratcliffe, 2010; Ceccato & Uittenbogaard, 2013; Newton & Felson, 2015). Crime 'hot spots' are the geographic areas that experience higher rates of certain crimes. The identification of crime hot spots has been in use for at least 100 years (Block & Block, 1995). Studies of hot spots often focus on the demographic or land use patterns that are associated with crime. For example, Twinam (2017) in Chicago in the United States and Haider and Iamtrakul (2022) in Chittagong City, Bangladesh both studied the urban land use patterns driving street crime. Studies such as Ratcliffe (2004) developed a more nuanced analytical approach to spatial analysis through the incorporation of shorter periods of time.

Spatial analyses of rural crime are less common. Ceccato (2016) used geographic information system (GIS) data in her analysis of rural crime in Sweden and found evidence of spatial clustering of property theft and seasonal patterns to crime in tourist areas.

Space-time interaction can be a critical part of understanding patterns in crime (Grubesic & Mack, 2008). Whether certain types of crime tend to occur in clusters within a short period of time or in isolation can inform police about the utility of increasing police presence in an area. For example, Johnson et al. (2007) found that a residence is at a greater risk of burglary for at least two weeks if it is within 200m of a burgled home. Using annual data can result in overlooking important seasonal patterns or spikes in crime.

We use data on goat farmers in Jamaica to explore the space-time patterns in livestock theft. Most of the literature on agricultural theft uses cross-sectional data that focuses on the costs or attributes of the location or farmer.[1] Our contribution to the literature is to demonstrate that there are strong space-time interactions in theft that are important for

[1] A notable exception is the recent work by (Dyer, 2023) who used a randomized controlled trial to improve security by subsidizing watchmen.

understanding the nature of the crime and that would be missed in cross-sectional or annual data.

We assemble a 36-month retrospective panel that allows us to control for farmer characteristics. In particular, we look at the time of year and timing of theft in relation to other nearby incidents of theft. We find a strong seasonal pattern to goat theft in Jamaica – nearly half of all thefts occur in November and December and farmers face a roughly 10% risk of theft during this time as demand for goat meat increases before the holidays. We also find that the probability of theft increases with the number of incidents of theft from nearby farmers, but decreases in the total number of livestock stolen. The results are suggestive of three types of theft: opportunistic theft of a single animal uncorrelated with nearby theft; clusters of correlated thefts within a given month; and large-scale, organized theft from a single farmer.

Livestock Theft

The mobility of larger livestock (i.e., cattle, goats, sheep) makes livestock theft somewhat distinct from theft of crops or machinery. Animals can be herded off on foot or into waiting vehicles. This makes large-scale theft easier and faster compared to, for example, crops that must be picked and carried off. Unlike crops, however, there is a greater potential for identification of individual animals using tattoos, brands, or other technologies if regulations can be enforced in markets before slaughter.

Fafchamps and Moser (2003) studied crime in relation to geographic isolation in Madagascar and found that rates of all types of crime are higher in areas with lower populations, but that effect is highest for cattle theft. Theft of cattle increased following large increases in fuel and transportation costs during a political crisis (Fafchamps & Minten 2006). Furthermore, cattle theft seems to be primarily an organized crime in Madagascar. Cattle thieves move cattle to distant markets that are willing to take them without required documentation.

While data on livestock theft is not widely available, for comparison we can use the five-year crime victim prevalence rate for five African countries reported in the 2000 International Crime Victim Survey (Naudé, 2006). As shown in Table 1, they found a range of 32 to 44 percent of livestock-owning households reporting a theft in the previous five years. A separate study from Malawi in 2004 found that 19.4 percent of livestock-owning households had experienced theft in the previous year (Sidebottom, 2013). Both of these studies included poultry theft, which tends to be more common than larger livestock (Sidebottom, 2013).

According to a report on agricultural theft in Jamaica by Graham (2014), agricultural producers suffer hundreds of millions of dollars of direct losses each year and are at risk of violence at the hands of perpetrators. While the lack of systematic reporting makes precise estimates impossible, losses in the livestock sector appear to be particularly high and the theft and subsequent sale of animals appear to be part of a well-organized system. Livestock theft

is so pervasive that the sale of stolen animals on the market may have a secondary effect of keeping prices low, further impacting profitability of the sector. This scenario is similar to that portrayed by Bunei and Barasa (2017) in Kenya wherein there is an ostensible systemic nature to theft with supply chain implications.

Table 1

Theft of Livestock over a five-year period, International Crime Victim Survey 2000

	Percent Ownership	**Percent owners experiencing theft**	**Percent of incidents reported to police**
Botswana	35.4	31.8	48.1
Lesotho	21.0	43.4	45.6
Namibia	26.5	31.5	51.8
South Africa	7.2	34.4	36.4
Zambia	19.4	43.6	19.

Source: Naudé et al (2006)

Local goat meat in Jamaica is favored by consumers but faces competition from substantially cheaper imported mutton. Although goats are common in rural areas, there are few producers that are raising on a large enough commercial scale to satisfy the demand. A principal reason for why there are not more and larger producers is the threat of theft and potential corporal harm (Mundle, 2018). The socio-economic causes of livestock theft are similar to those found in studies of production areas that are connected to urban centers (Bunei et al., 2013) and include factors such as high youth unemployment, social disorganization, and lack of family structure. This differs from the predatory ethnic and community destabilization reasons identified by studies of cattle rustling in remote areas of Africa (Greiner, 2013).

Some cases of theft in Jamaica have been linked to organized crime. The *Jamaica Observer* reported that goat theft was being used to finance gangs in the parish of Clarendon (Helps, 2018). In the year 2017, a total of 15 murders and 18 shootings were attributed to agricultural thefts. The article goes on to say that in the first months of 2018, eight murders and six shootings were linked to praedial larceny activities. There are reports of goat farmers switching to other activities because of theft and violence (Mundle, 2018; Virtue, 2021). One farmer reported that theft of many animals at once was becoming more common.

Legislative and Policing Framework

Laws against theft and destruction of agricultural goods were in place even before Jamaica gained independence from the United Kingdom in 1962. Under the 1942 *Larceny Act*, Sections 6 (livestock theft – 1984 revision), 7 (killing livestock – 1984 revision), 13 (crop theft or destruction – 1973 revision), and 49 (theft of fish, crustaceans, mollusks, and turtles – 2000 revision) were introduced for agricultural goods. The harshest sentence for

sections 6, 7, and 49 is three years imprisonment and for section 13 three months of hard labor. Although these sentences are relatively severe, those that are convicted are usually given the minimal sentence, which are simply fines (a maximum of $300 USD for livestock and fish, and $40 USD for crops). Due to this, the disincentive is insignificant. In addition to these laws, a *Praedial Larceny (Prevention) Act* was enacted in 1984 that introduced agricultural wardens to the Jamaica Constabulary Force (JCF).

In 2004, the *Agricultural Produce Act* was amended to include a suite of traceability policies for all agricultural goods. All farmers are supposed to keep receipt books that include the transport vehicle information, description of goods, the amount of the goods, and buyer and seller information. Each actor involved must retain a copy of the receipt and one must be provided to the nearest police station to the point of sale. If any of the buyer, seller, or transport is not able to produce the receipt when requested by the police then the goods can be confiscated and all actors involved in the transaction will be investigated. Under this system, authorities keep a centralized data base of farmers and police can call in to verify the origin of products. However, farmer participation in the program has been low and corruption is reportedly high. Only 20 percent of registered producers had receipt books and only 40 percent of those issued receipts (Graham, 2014).

Other measures include the following: the assignment of a JCF praedial larceny officer for each parish; school education campaigns; sensitization of judges on the Larceny, Praedial Larceny Prevention and Agricultural Produce Acts; public awareness campaigns, requiring cattle farmers to adopt government issued Electronic Identification (EID) ear tags; and the creation of the Praedial Larceny Prevention Unit (PLPU) in 2015 which is a joint task force between the Ministry of Agriculture, Fisheries and Mining (MOAFM) and the Ministry of National Security (MNS). Furthermore, a National Committee on Praedial Larceny was created in conjunction with the PLPU to provide policy oversight and guidance.

Data and descriptive statistics

We conducted a survey in early 2019 in four parishes of Jamaica. Names for the sampling frame were obtained from a list of known goat farmers. The list was constructed by one of the authors for a separate project on designing a national small ruminants farmer cluster system for the (MOAFM). This involved travel to every parish wherein extension officers guided the author to all known commercial producers in their extension area, asking every recommended commercial producer to recall small ruminant farmers that they know, reviewing the national small ruminants association membership list, and reviewing the national farmer database. This resulted in 209 names, and we were able to reach and interview 175 farmers. All farmers on that list who had ten or more goats at some point since 2016 were deemed eligible to participate in the survey. The minimum number was chosen to distinguish those raising goats for income from those keeping a few animals for home consumption or occasional sale.

The farmers surveyed were smallholders with diverse income sources, which is typical in rural Jamaica. The survey collected household characteristics, livestock holdings,

crime victimization, and willingness to report to the police and willingness to pay for crime reduction. The focus was on goats, because, as discussed above, this is the most common livestock and the primary target of thieves, although the survey did include questions about cattle, sheep, and pigs as well. The survey included questions on livestock holdings and incidents of theft from January 2016 to January 2019.

Table 2 displays the basic characteristics of the farmers and Table 3 summarizes the stock levels over time for all livestock. Both the mean and median number of goats owned declined over time—both falling by half between 2016 and 2019. Figure 1 shows the box plot of goat stocks between 2016 and 2019. The largest decrease was reported between 2018 and 2019. This decline is not driven by farmers who quit raising goats altogether or by missing observations due to inability to recall earlier years.

Table 2

Farm and farmer characteristics

Variable	Obs	Mean	Std. Dev.
Goats (units of 100)	166	40.70	54.48
No spouse	166	0.373	0.485
Household size	166	3.542	1.781
Head age	166	52.590	13.215
Head sex (1 = male)	166	0.801	0.399
Head education (1 = completed secondary)	166	0.380	0.485
Head is a farmer	166	0.825	0.381
Head is only a farmer	166	0.446	0.499
Spouse age	166	29.048	25.069
Spouse education	166	3.843	15.062

Because we targeted goat farmers, not surprisingly, the number of farmers in our sample who also keep cattle, sheep, and pigs is lower and we cannot say much about these sectors specifically. However, we do see that the number of farmers who own cattle and the median number owned increased over the period. The number raising sheep and pigs also increased slightly, although the median number owned fell. This suggests that the decline in the number of goats is not due to factors affecting other livestock.

Table 3

Livestock holdings 2016-2019

	mean	sd	max	N>0	Median if N>0
Goats 2019	27.6	38.0	300	161	15
Goats 2018	41.1	54.7	400	166	25
Goats 2017	48.4	65.4	500	157	26
Goats 2016	54.8	79.8	700	139	30
Sheep 2019	5.5	24.0	200	17	30
Sheep 2018	5.8	26.3	200	17	35
Sheep 2017	6.4	30.2	250	15	40
Sheep 2016	5.9	31.3	300	12	48
Cattle 2019	3.1	10.7	100	36	7.5
Cattle 2018	3.5	12.5	96	34	6.5
Cattle 2017	2.2	7.1	40	29	7
Cattle 2016	2.0	9.7	80	17	4
Pigs 2019	2.8	10.0	80	36	6.5
Pigs 2018	7.1	24.4	200	44	8.5
Pigs 2017	6.9	25.5	200	34	15
Pigs 2016	4.8	27.3	300	23	10

For farmers whose goat herd sizes fell, loss due to theft was the most frequently given reason for the decline, named in nearly 48 percent of cases (Table 4). The next most common reason was sale of animals (23% of cases). Nearly 87 percent of farmers said they would like to expand their herds. Again, theft was the most frequently cited reason for not expanding (38% of farmers), followed by lack of credit (20%).

Table 4

Reasons cited for herd reduction and obstacles to expansion

What was the most important reason for the reduction in herd size?	Percent
Loss due to theft	47.62
Sold animals	23.49
Loss due to disease	15.56
Other	13.33

What is the major reason you do not expand your herd?	
Can't protect them from thieves	38.1
Can't get a loan to invest in expansion	20.41
Don't have enough labor available	6.8
Don't have enough feeding area	5.44
Don't have enough space to pen them	6.8
Animal disease	3.4
Other	19.05

Figure 1

Box plot of goat stocks by year

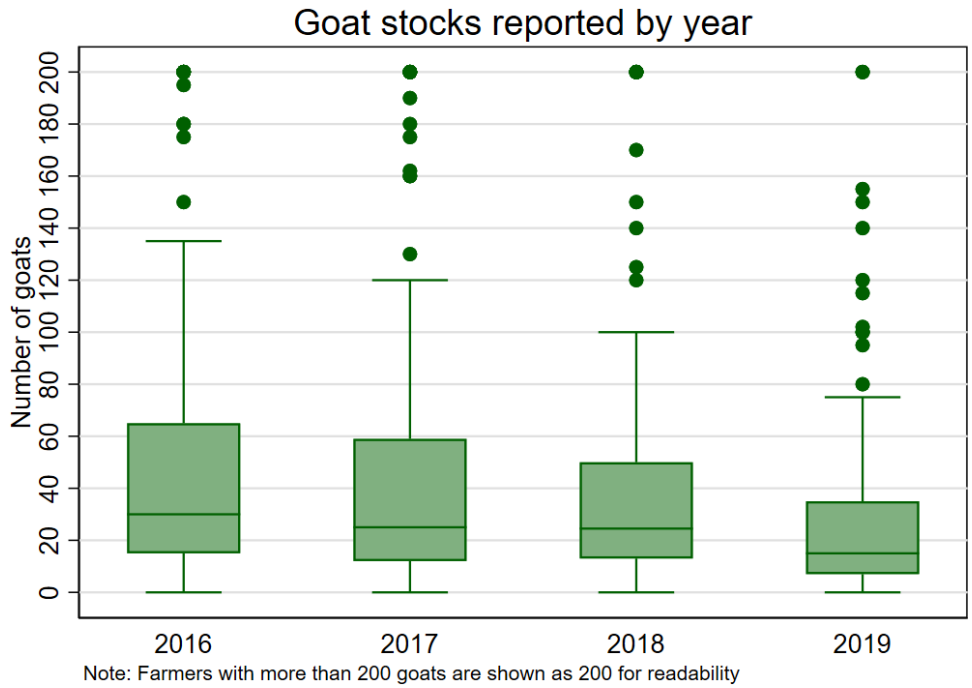
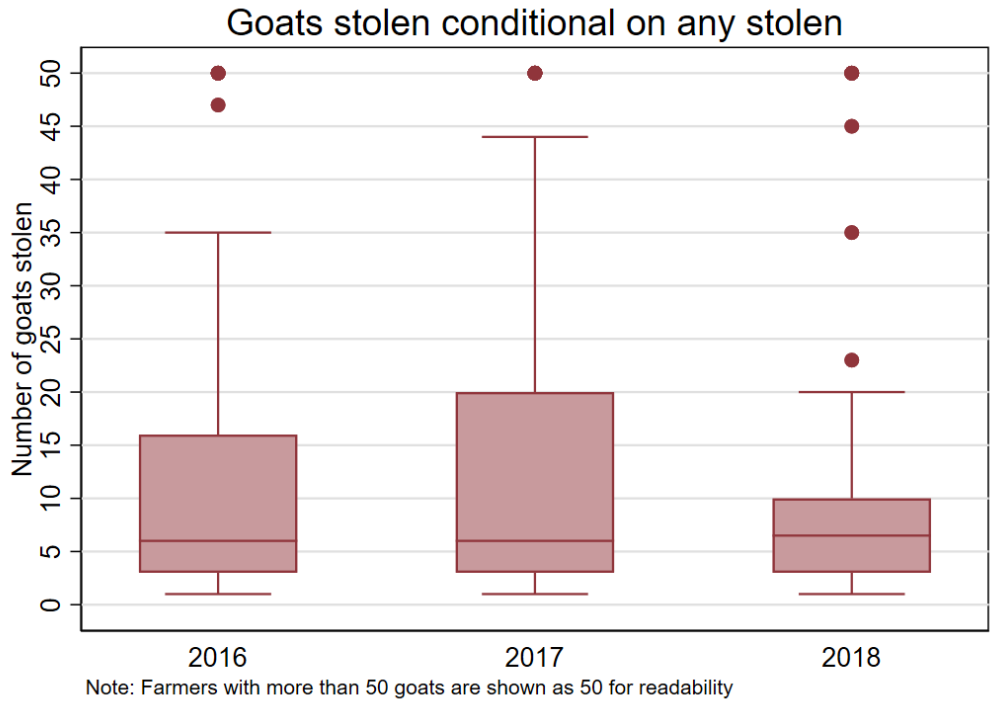


Figure 2

Box plot of the number reported goats stolen conditional on any stolen



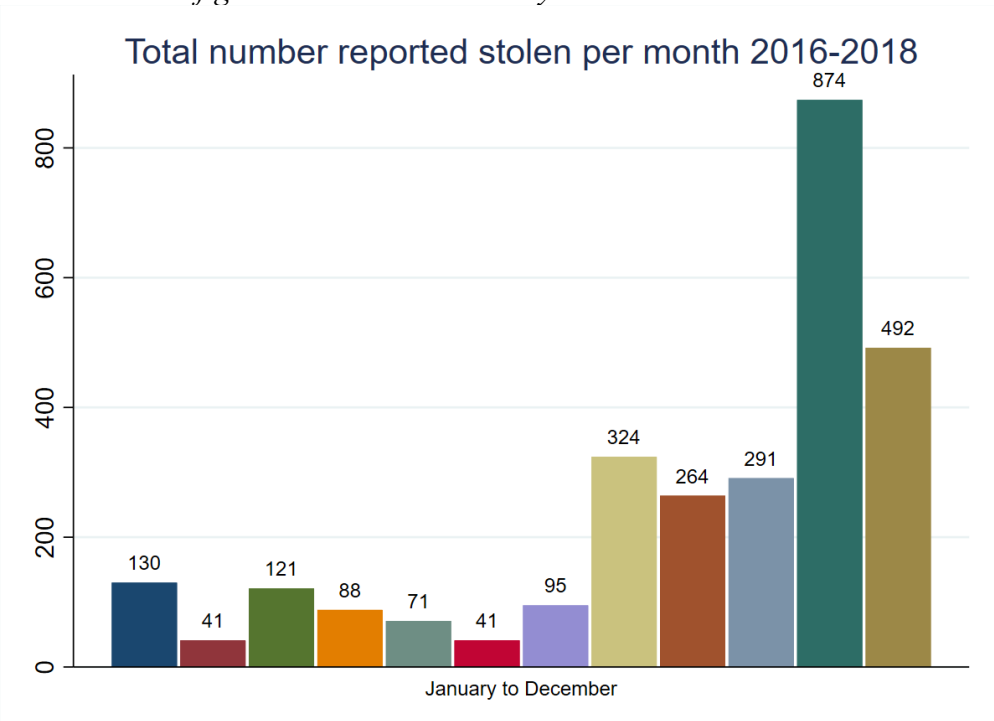
Theft

The survey recorded all incidents of goat theft for the 3-year period 2016-2018. One of the issues with collecting livestock theft data is the potential for conflation with reasons for loss such as animal predation and straying. Dogs are the only animals that attack goats in Jamaica, and they do not carry away goats after an attack. Thus, the goats that suffer from dog attacks will be left at the attack site. Therefore, there will be clear evidence of an animal attack as compared to theft. Also, goats are led in herds and become attuned to their base location and feeding route. This means that goats do not wander to unfamiliar areas due to the production system. For these reasons, we are confident that we are capturing true criminal theft.

For each theft incident, we asked about the number stolen, the month and year, and whether the farmer reported the theft to the police. Over the three-year period (2016-2018), 60 percent of farmers had at least one incident of theft. The median farmer lost four goats to theft. While stocks declined over the period, the number of farmers reporting theft in each year was stable (59-60 out of 169), as was the median number stolen (6-6.5) conditional on any theft. Fifteen percent (26 farmers) reported incidents of theft in each of the three years. Figure 2 shows the reported cases of theft by year for farmers reporting any theft and Figure 3 shows the total reported thefts in the sample by month.

Figure 3

Total number of goats stolen 2016-2018 by month



Empirical Strategy

The retrospective questions recording the livestock holdings and incidents of theft allow us to construct a panel data set. Because we are primarily interested in the spatial and

temporal dimensions of crime, we create a data set by month from 2016-2018, giving us potentially 36 observations for each of the 169 farmers, or 6,084 observations. This allows us to use farmer fixed effects to control for farm and farmer characteristics. While we only have stocks for the beginning of each year, we chose to create the monthly panel rather than a yearly one because aggregating theft to an annual level does not allow us to explore seasonal patterns and local spikes in theft. In the estimations we present here, we drop observations for which the farmer reported zero goats at the beginning of that year. Our dependent variable is the number of goats stolen from the farmer in a given month.

Because of the numbers of zeros, we use the inverse hyperbolic sine transformation of the number of goats stolen (Bartlett, 1947). When a dependent variable is always positive and is skewed to the right, it is common to take the logarithm of it either to satisfy theory or to reduce the skewness and achieve an approximately Gaussian distribution. That is derived from Bartlett (1947), which presented a list of Bartlett's transformations. The logarithm loses all values of 0, which creates selection bias in estimation. An alternative transformation for dependent variables skewed right and with many values of 0 is the inverse hyperbolic sine (invsinh), which is another of Bartlett's transformations.[2] Then the inverse hyperbolic sine of the number of goats stolen becomes the dependent variable, and the fitted values are transformed back by the hyperbolic sine for graphing.

Clustered standard errors are recommended to correct for serial correlation in panel data (Bertrand et al., 2004). Bertand et al. (2004) show that for the case of difference-in-difference estimation, serial correlation can lead to over-rejection of the null, particularly when there are many time periods. In our case, if theft was serially correlated in our data, we might find a relationship between local cases of theft when in fact there was none. We test for serial correlation in our main estimations and fail to reject the null of no serial correlation[3] (Cooperman, 2017; Ferman, 2019). Furthermore, we did not use a clustered random sampling, which is the primary reason for doing clustering (Abadie et al., 2017). Second, even if we cluster by locality, we have very few clusters. Therefore, we do not cluster our standard errors. Farmer fixed effects also control for locality, as the farmers do not move.

One of our main interests in this article is testing for local crime sprees at a point in time, controlling for farmer (and therefore location) fixed effects. This implies that nearby cases of theft would be predictive of theft from an individual farmer in that month. There are several ways to measure local incidents of theft, including all reported thefts within a certain distance and thefts among the nearest *x* number of farmers. Each of these, in turn, can be measured in number of incidents or number stolen. Our preferred specification includes both the number of goats stolen and the number of incidents in a given month reported by the nearest five neighbors within 10km. This measure is summarized in Table 5. We do this

[2] If $y = \sinh(x) = (e^x - e^{-x})/2$, $x = \text{invsinh}(y) = \ln(y \pm \sqrt{(y^2 + 1)})$, and the positive square root is required for x to be nonnegative. Near 0, y is approximately x, linear, and for large y, x is approximately ln(y) + ln(2). The two approximations are equally close at about x = 1.121768. This transformation links a linear value near 0 to a logarithm above 0.

[3] We use the bias-corrected Q(P) statistic for serial correlation described in Born and Breitung (2016). Estimate p-values for these tests ranged from 0.49 to 0.72.

using linear distance based on the farmer's home coordinates taken at the time of the survey. For robustness we also estimate models using cases of theft and number of animals stolen for all farmers within 5 kilometres and 10 kilometres.

A potential concern is that unobserved spatial correlation could be driving the effect of nearby theft. For example, neighbors may share certain vulnerabilities such as proximity to a road or having similar farm layouts. However, these examples are likely time-invariant over the relatively short three year time frame of our study and thus would be controlled by farmer fixed-effects estimations.

In addition to the fixed-effects panel model, we also explore the time-invariant farm and farmer characteristics associated with theft. In this model, we include characteristics of the household head including age, gender, education, and primary occupation. Other variables include herd size, household size and characteristics of the spouse. These variables are summarized in Table 2.

Table 5

Number of goats stolen from nearest 5 neighbors within 10 km

Goats stolen	Number of farmer-months	Percent
0	5,092	84.7
1	80	1.33
2-5	346	5.76
6-10	231	3.84
11-20	145	2.41
>20	118	1.96

Monthly observations 2016-2018

Results

Table 6 presents results of our panel model specification. The number of goats stolen is increasing in the number of thefts, meaning that if there are more incidents of local theft, theft is more likely. At the same time, however, if a large number of animals are stolen locally, an additional theft is less likely. This suggests that thefts tend to occur in clusters or in large, single events. Not surprisingly, the number of goats stolen is increasing in the number owned but at a decreasing rate. Consistent with Figure 3, thefts are more likely to occur in November and December. Table 1 presents the results using the alternative measures, nearby theft based on thefts within 5 or 10 kilometers. The results are consistent with those in Table 6.

Table 6

Regression of the inverse sine transformation of the number of goats stolen

Explanatory variable	Coef.	Std. Err.	
Thefts 5 nearest neighbors	0.049	0.016	**
Goats stolen 5 nearest neighbors	-0.002	0.001	*
Goats owned (units of 100)	0.178	0.047	**
Goats squared (units of 10000)	-0.021	0.007	**
Month relative to January			
February	-0.061	0.033	
March	-0.045	0.033	
April	-0.039	0.033	
May	-0.046	0.033	
June	-0.063	0.033	
July	-0.035	0.033	
August	0.028	0.033	
September	0.029	0.033	
October	0.062	0.033	
November	0.189	0.034	**
December	0.098	0.033	**
Constant (January)	0.012	0.030	
Number of farmers	166		
Number of farmer-month obs	5592		
R2 overall	3.3		

**Statistically significant at p<0.01, *statistically significant at p<0.05.

Figure 4 plots the effects of herd size on theft under different scenarios based on the table 6 results. The top line shows the case of a large number of local incidents (the mean, 0.2 plus 2 standard deviations) and a small number of animals stolen (the mean, 2 animals). The bottom line shows the case of a small number of incidents (the mean, 0.2) and a large number of animals stolen (the mean plus 2 standard deviations, 20 animals). The middle line is the case of no local theft. The red horizontal line represents the mean number of animals stolen. The figure demonstrates that when there is a larger number of incidents but with fewer total animals stolen, the risk of theft is higher, consistent with a local crime spree. However, when a large number of animals are taken over fewer events, the risk of theft is actually lower compared to no local thefts.

Figure 4

Predicted number of thefts in November under different scenarios

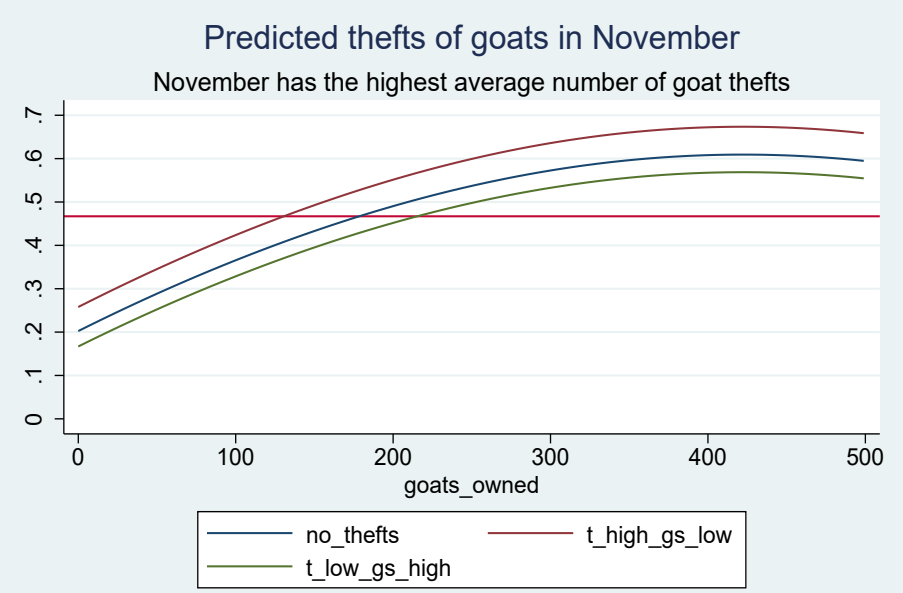


Table 8 shows the regression of the fixed effects on household characteristics. Average levels of theft increase if there is no spouse or the spouse is older. Having a spouse present may improve security by reducing the time the goats are unattended. Interestingly, those who identify primarily as farmers are more likely to be victims.

Discussion

There are several features of our data that limit the present study. First, the sample was composed of all known commercially oriented farmers in a given area by including only farmers who had kept at least 10 goats. Therefore, we cannot say how crime affects the many rural Jamaicans who keep only a few animals and if theft of their animals is correlated with theft from farmers with more animals. Second, we do not take into account the security measures of farmers and are unable to say what individual measures help secure livestock. Third, we only asked farmers about livestock theft and we do not know if these thieves only target livestock or if crops or other items are stolen as well. This is important information for the police and policy makers.

Table 7

Regression of the inverse sine transformation of the number of goats stolen on alternative measures of theft

	5 km			**10 km**		
Explanatory variable	**Coef.**	**Std. Err.**		**Coef.**	**Std. Err.**	
Thefts within _ km	0.030	0.007	**	0.026	0.005	*
Goats stolen within _ km	-0.001	0.001	*	-0.002	0.000	*
Goats (units of 100)	0.179	0.047	**	0.176	0.046	*
Goats squared (units of 10000)	-0.021	0.007	*	-0.021	0.007	*
Relative to January						
February	-0.047	0.034		-0.046	0.033	
March	-0.032	0.034		-0.031	0.033	
April	-0.025	0.034		-0.024	0.033	
May	-0.034	0.034		-0.032	0.033	
June	-0.053	0.034		-0.052	0.033	
July	-0.023	0.034		-0.024	0.033	
August	0.036	0.033		0.036	0.033	
September	0.029	0.033		0.021	0.033	
October	0.062	0.033		0.048	0.033	
November	0.172	0.035	*	0.162	0.036	*
December	0.097	0.033	*	0.102	0.033	*
constant	-0.002	0.030		-0.002	0.030	
Number of farmers	166			167		
Num of farmer-month obs	5592			5628		
R2 overall	3.5			3.5		

There have been two major developments in farm crime policing and legislation. In December 2023 Parliament amended the farm crime legislation by increasing the praedial larceny penalty from a fine of JMD 250,000 or 3 months in prison to JMD 3,000,000 or 3 years in prison. In 2024, the MOAFM PLPU began implementing an expansive agricultural warden program wherein 300 police officers dedicated to farm crime are being hired and trained over the next 3 years. These efforts are commendable and expected to significantly impact farm crime. However, a research driven approach should be integrated into the new policing initiative. Criminal targeting requires scientifically derived information for law enforcement strategies to be effective. The unique spatial-temporal analysis that was performed here is a clear example. The results indicating that theft occurs within a specific distance, in an area with a certain concentration of farmers, and at specific times of the year will enable police to maximize limited resources. This is particularly pertinent to lower income countries that have constrained police funding, and a larger portion of the population

that is dependent on agriculture. This makes us confident that our work can guide studies of livestock theft in other contexts as the results have practical application.

Table 8

Regression of the fixed effects on household characteristics

Explanatory variable	Coef.	Std. Err.	
Goats (units of 100)	-0.047	0.039	
No spouse	0.271	0.104	*
Household size	0.001	0.006	
Head of household age	-0.007	0.005	
Head of household age square	0.000	0.000	
Head of household gender (1 =M 2 =F)	0.011	0.019	
Head of household education	0.000	0.000	
Head is a farmer	0.047	0.021	**
Head is only a farmer	-0.021	0.021	
Spouse age	0.01066	0.00477	*
Spouse age Square	-0.00009	0.00005	
Spouse education	0.000	0.001	
Constant	-0.122	0.099	
Number of farmers	166		
R2 overall	9.9		

Conclusion

Using data from goat farmers in Jamaica, this article shows strong space-time patterns in theft. Theft is highly seasonal, with theft most likely to occur before the Christmas holidays in November and December. While we find no evidence of spatial auto-correlation in cross-section, or even by year, we do find evidence of local crime sprees. The probability of theft is increasing in the number of nearby incidents of theft but decreases in the number of animals stolen.

What do we make of these results? First, theft is pervasive. While the number of animals stolen is higher in large herds, having a large herd is not related to the likelihood of theft. The majority of farmers had experienced theft in the previous three years. Second, we identify distinct types of theft in our data – opportunistic, local sprees, and single, organized, large scale events. Opportunistic thefts are one-off thefts of a single animal that are unrelated to a neighboring farmer's likelihood of having goats stolen in that month. However, as the number of local thefts increases, the likelihood of a theft increases, suggestive of a crime spree.

Finally, large numbers of animals stolen locally reduce the likelihood of theft. Large events likely make local farmers more vigilant and deter other thieves. For local police and

farmers, collecting information on small scale thefts and quickly disseminating that information might help farmers take mitigating action or help police identify areas that temporarily need extra policing.

While large-scale theft needs to be investigated, extra policing of that area may not be warranted. For farmers in Jamaica, the situation is dire. There is strong consumer demand for local goat meat, yet theft is the single most common reason for both herd reductions and reluctance to expand. The risk of theft reduces investment in a sector that should be profitable.

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