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Authors

Quinn, Niamh
Fox, Dan
Hartman, Jim

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An Examination of Citizen-Provided Coyote Reports: Temporal and Spatial Patterns and Their Implications for Management of Human-Coyote Conflicts

Niamh Quinn

Cooperative Extension - Orange County, University of California, Irvine, California

Dan Fox

Animal Pest Management Services Inc., Chino, California

Jim Hartman

Department of Agricultural Commissioner/Weights and Measures, County of Los Angeles, Arcadia, California

ABSTRACT: In many cities across the United States, incidences of coyote encounters (*Canis latrans*) and human-coyote conflicts are rising. This is especially true for cities in Southern California, where conflicts including pet attacks have been recorded since the 1960s. The only coyote-related human fatality in the United States occurred in Southern California in 1981 and, although no fatal attacks have occurred since, coyote bites to humans are still occurring. Coyote attacks on pets appear to be common in Southern California; however, data are lacking in this area of human-coyote conflicts. This paper examines data from multiple sources that record human-coyote conflicts in Southern California. Coyote reports have been more frequently received by the entities involved in this analysis as their recording time progresses, with data from 243 cities and unincorporated areas suggesting that the majority of reports (68%) are related to non-conflict events. Conflicts were significantly higher in the pup-rearing season compared to the breeding season. There appears to be spatial clustering of coyote reports from Los Angeles County; however, complex analysis is needed to determine the relationship between frequency of complaints and land use in all of the counties to help determine what is driving human-coyote conflicts in Southern California.

KEY WORDS: *Canis latrans*, citizen science, coyote, human safety, human-wildlife conflict, Southern California, urban coyote, wildlife management

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INTRODUCTION

In many cities across the United States, incidences of human-coyote conflicts are on the rise. This is particularly true for urban and suburban areas of Southern California where conflicts appear to be common and have been reported since the 1960s (Gill 1965). Urbanization and urban sprawl have been implicated as the cause of many behavioral changes and conflicts concerning wildlife (Riley et al. 2003, Lewis et al. 2015).

The only coyote-related human fatality in the United States occurred in Southern California in 1981, when a three-year-old girl was attacked and killed in Glendale, Los Angeles County (Howell 1982). However, there is a continuing upward trend of non-lethal coyote bites, particularly in Southern California (Timm et al. 2004). In 2015, there were 24 coyote bites on humans in Southern California (pers. comm., California Dept. of Fish and Wildlife, and Los Angeles Co. Dept. of Public Health). This is almost a two-fold increase of the numbers reported for 2001 by Timm et al. (2004); coyote attacks on humans in California in 2001 were at their highest for the recording period (1978-2003) during that year. Few studies have been conducted in urban Southern California on coyote ecology or on human-coyote conflicts in the region, thus little is known about what drives these conflicts.

One of the most frequent conflicts occurring in Southern California involves coyote attacks on domestic pets, particularly dogs and cats. Historically, data have been lacking on these types of conflicts. Nearly two decades

ago, it was suggested that state and local officials needed to commence collection of data on coyote attacks on domestic pets and humans in order to improve the understanding of the existing problems in the state (Baker and Timm 1998). Many agencies in Southern California are now recognizing that these pet takes are major parts of human-coyote conflict, and some records are now being maintained by cities, county agencies, private industry, and state agencies.

Previous studies have shown that there are temporal and spatial patterns to human-coyote conflicts (Lukasik and Alexander 2011, Poessel et al. 2013). This paper aims to examine data from several entities to determine if temporal and spatial trends in human-coyote conflicts in Southern California are also occurring.

METHODS

Study Area

For the purpose of this paper, Southern California is defined as the following counties: Imperial, Kern, Los Angeles, Orange, Riverside, San Bernardino, San Diego, San Luis Obispo, Santa Barbara, and Ventura. The area totals 155,114 km² and ranges in elevation from 86 m below sea level to 3,506 m above sea level. According to the 2010 census data, the population of the region totals 18,096,701, with several counties in Southern California among the top ten most populated counties in the United States. Natural habitats include but are not limited to chaparral, oak woodland/savannah, montane forest, desert montane, and riparian forests. Southern California boasts

extensive national recreation areas, multiple state parks, and hundreds of city parks.

Human-Coyote Encounter and Incident Data Collection and Analyses

Data were obtained from coyote reports provided by six different entities with recording times varying between these entities but covering a period of time spanning January 2000 and January 2016 (Table 1). The majority of these coyote reports involved the recording of information obtained from phone calls to the entities from citizens of Southern California. Information on the collection of coyote carcasses from vehicle collisions was also recorded by one entity. Data in coyote reports were divided into date, city, county, type of coyote report (conflict or non-conflict) and biological season. Biological seasons were defined as breeding (January-April), pup-rearing (May- August), and dispersal (September- December). The types of coyote report were further subdivided into several categories:

1. Sightings only
2. Coyote appears to be not afraid
3. Roadkill
4. Conflicts involving pets
5. Conflicts involving pets and people
6. Conflicts involving people
7. Livestock attacks

Entities used a variety of these subdivisions; some entities did not use any subdivisions, and so detailed descriptions were used and a report-type subdivision was assigned to each report. Only one entity recorded roadkill instances. Often multiple subdivisions were assigned to each coyote report. One entity recorded the disposition of coyotes as: aggressive to people; aggressive to pets; shy; not afraid; and odd behavior. After reading detailed descriptions of these coyote reports, it was considered whether or not these dispositions were accurate, and a subdivision was assigned based on these considerations. Coyote reports were often incomplete, with missing information regarding date, city, county, and type of report made;

these were recorded as unknown. For several years, the Los Angeles County Agricultural Commissioner recorded some conflicts as “aggressive to people or pets.” It was often difficult to tell from the narrative whether the conflict involved people or pets or both.

It should be noted that the data collected have the potential to be biased due to the efforts of collecting, recording, and reporting by each of the different entities and citizens involved. Some entities did not include detailed descriptions with their reports, and therefore the subdivision already assigned could not always be verified. Also, in Southern California many entities are recording coyote-related data. Efforts were made to reach out to many entities; however, some did not collect data, and some have thus far not provided the requested data. Other Southern California entities may be collecting coyote reports and a request for this data may have not been made by the senior author. All of these situations involving absent or missing data may result in further bias.

RESULTS

Coyote reports were obtained from six different entities totaling 11,103 reports (Table 1) with an additional 1,434 reports of roadkill also reported by one entity. These coyote reports comprised a total of eight Southern California counties, with the majority of coyote reports from Los Angeles, Orange, and San Bernardino Counties. Agencies generally only recorded coyote reports within their jurisdiction: Los Angeles County, Department of Agricultural Commissioner, for certain areas within Los Angeles County; County of San Bernardino Animal Services for San Bernardino County; Orange County Animal Care for specific areas within Orange County; Irvine Police Department for the city of Irvine; and Huntington Beach Police Department for the city of Huntington Beach. The California Department of Fish and Wildlife’s Wildlife Incident Log had reports from eight different counties, but the majority of reports came from Los Angeles and Orange Counties.

Table 1. Name of entity, recording period for information gathered, and number of coyote reports gathered from named entity.

Entity	Recording Period	Number of Coyote Reports
California Department of Fish and Wildlife	April 2013 - January 2016	407
City of Huntington Beach	January 2014 - October 2015	594
Irvine Police Department	January 2011 - December 2015	3,087
LA Co., Department of Agricultural Commissioner	February 2007 - October 2015	3,240
Orange County Animal Care	May 2000 - October 2015	1,480
San Bernardino County Animal Services	October 2003 - December 2014	2,295

Table 2. Results of chi square analysis examining significant differences between numbers of coyote reports collect in first year of recording compared with final year. Only complete years were considered.

Agency	χ^2	df	p
California Department of Fish and Wildlife	47.79	1	***
Irvine Police Department	360.6	1	***
LA Co. Agricultural Commissioner’s Office	19.56	1	***
Orange County Animal Care	23.56	1	***
San Bernardino County Animal Services	4.41	1	*

Table 3. Results of chi squared test investigating relationship of coyote reports and biological season are displayed with Source in first column. Post-hoc results of chi-squared test for which biological season was significantly different is displayed in the other columns. The biological season with significantly higher coyote reports for the post hoc analysis is indicated in bold.

Source (χ^2 result)	Biological Season	χ^2 (post-hoc)	p
California Department of Fish and Wildlife ($\chi^2 = 34.92$, df = 2, ***)	Breeding v Pup-rearing	35.02	***
	Breeding v Dispersal	21.76	***
	Pup-rearing v Dispersal	1.74	NS
Irvine Police Department ($\chi^2 = 252.68$, df = 2, ***)	Breeding v Pup-rearing	156.21	***
	Breeding v Dispersal	267.33	***
	Pup-rearing v Dispersal	16.01	***
LA Co., Department of Agricultural Commissioner ($\chi^2 = 88.06$, df = 2, ***)	Breeding v Pup-rearing	85.96	***
	Breeding v Dispersal	22.09	***
	Pup-rearing v Dispersal	21.28	***
Orange County Animal Care ($\chi^2 = 58$, df = 2, ***)	Breeding v Pup-rearing	53.31	***
	Breeding v Dispersal	44.58	***
	Pup-rearing v Dispersal	0.41	NS
County of San Bernardino Animal Services ($\chi^2 = 36.85$, df = 2, ***)	Breeding v Pup-rearing	36.12	***
	Breeding v Dispersal	10.03	**
	Pup-rearing v Dispersal	8.16	**

There were 10,978 classifiable reports, 68% (7,432) of which could be described as non-conflict (sightings only). The remaining 32% (3,546) were classed as conflict reports. Sightings were the most common coyote reports made, with the remaining reports varying on a scale from potential conflict (coyotes appear to be not afraid) to serious conflict, which included coyote bites on humans. The number of coyote reports involving human-specific conflicts was lowest in the data provided by the cities of Irvine and Huntington Beach but considerably higher in the reports by Los Angeles County, Department of Agricultural Commissioner.

Conflicts involving humans and coyotes were significantly different between Los Angeles, Orange, and San Bernardino Counties ($\chi^2 = 198.11$, df = 2, $p < 0.0001$). These types of conflicts were the highest in Los Angeles County, with 104 incidents over a 108-month period. This number does not include 338 incidents that were classified as “conflict with person or pet” as it was not possible to distinguish from the report whether the conflict involved one or the other, or both. A total of 38 incidents over a 193-month period were reported from agencies within Orange County. Reports from San Bernardino County Animal Services were the lowest, with only nine reports over a 140-month period.

Coyote reports from entities in Southern California have been collected for as long as 186 months (14+ years) and as short as 24 months (Table 1). The proportion of coyote reports has been increasing each year, with the exception of 2005, 2010, and 2012, when the proportion of reports dropped slightly below the previous year. It should also be noted that the number of agencies collecting data has also increased since 2000. Although frequencies of coyote reports collected by agencies have fluctuated throughout their periods of collection, all agencies have shown a significant overall increase in the number of coyote reports at the end of the collection period compared with the beginning (Table 2).

Available coyote reports in Southern California were significantly different between biological seasons ($\chi^2 = 368.89$, df = 2, $p < 0.001$). Only complete years from entities that provided more than two years of complete data were analyzed. The number of total reports received in the breeding season was significantly less than the number received in both the pup-rearing season ($\chi^2 = 341.91$, df = 1, $p < 0.001$) and the dispersal season ($\chi^2 = 276.23$, df = 1, $p < 0.001$). There was no significant difference between the number of coyote reports received in the pup-rearing season and the number received in the dispersal season.

There were significant differences between the numbers of coyote reports received between the three designated biological seasons for all entities (Table 3). In all instances, the numbers of reports during the breeding season was fewer than expected, and the amount during the pup-rearing season was always more than expected (Figure 1). Coyote reports provided by Orange County Animal Care, California Department of Fish and Wildlife, and Irvine Police Department all had more calls than expected during the dispersal phase. Coyote reports provided by the Los Angeles County, Department of Agricultural Commissioner and by the County of San Bernardino Animal Services were slightly less than expected during the dispersal season.

A post-hoc chi squared test with a Bonferroni correction (adjusted alpha level) showed that coyote reports provided by all entities were significantly lower in the breeding season as compared to both the pup-rearing season and the dispersal season. The total numbers of coyote reports from the Los Angeles County, Department of Agricultural Commissioner and from the County of San Bernardino Animal Services during the dispersal season were significantly less than the reports from the pup-rearing season. Total coyote reports from Irvine Police Department during the pup-rearing season were significantly less than the reports received during the

Figure 1. Bar plot of proportions vs. biological season. Error bars indicate 95% confidence intervals for each observed proportion.

dispersal season. There was no significant difference between the number of reports between the dispersal season and the pup-rearing season in the data provided by Orange County Animal Care and Control, or by the California Department of Fish and Wildlife. The results of the post-hoc analyses can be seen in Table 3.

A post-hoc analysis was conducted with a Bonferroni adjusted alpha level for subdivisions of coyote reports. Coyote reports for sightings only were significantly lower in the breeding season when compared to both the pup-rearing season and the dispersal season in the data provided by the Los Angeles County, Department of Agricultural Commissioner, the County of San Bernardino Animal Services, Orange County Animal Care, California Department of Fish and Wildlife and Irvine Police Department. The only significant differences in the num-

bers of sightings reported between the pup-rearing season and the dispersal season was in data provided by Irvine Police Department, where the number of sightings was significantly higher in the dispersal season compared to the pup-rearing season. The results of the other post-hoc tests can be seen in Table 4.

In total, coyote reports came from 243 cities as well as unincorporated areas in Southern California. There were coyote reports from all 34 cities in Orange County, 72 out of the 88 cities in Los Angeles County, and all 24 cities in San Bernardino County. There also were reports from 23 other cities in Riverside, San Diego, Santa Barbara, San Luis Obispo, and Ventura Counties.

In Los Angeles County, the cities with the highest frequency of reports per capita appear to cluster somewhat in four areas: North Arroyo Seco Region, Palos Verdes

Table 4. Significance levels of chi squared test post-hoc analyses for sub categories of coyote reports. In all instances of significance for coyote reports from Los Angeles County, Department of Agricultural Commissioner (LAAG), the County of San Bernardino Animal Services (SBCo.), Orange County Animal Care (OCAC) and California Department of Fish and Wildlife (CDFW), the number of coyote reports in the breeding season were always less than the numbers in the pup-rearing and dispersal seasons. The numbers of coyote reports for the dispersal season were also all lower than the pup-rearing season in all instances of significance for these sources also. This was also true for all sub divisions of coyote reports from Irvine Police Department (IPD) except for the sighting only subdivision, where there were more coyote reports in the dispersal season than in the pup-rearing reason. NS means not significant and n/a is not applicable, since “not afraid” was not included in coyote reports from OCAC.

Biological Seasons	Source	Total	Sighting	People + Pets	People	Pets	Not Afraid
Breeding v Pup-rearing	LAAG	***	***	***	**	***	***
	SBCo.	***	***	***	NS	***	***
	OCAC	***	***	***	NS	***	n/a
	CDFW	***	***	***	NS	NS	NS
	IPD	***	***	***	NS	***	***
Breeding v Dispersal	LAAG	***	***	NS	NS	NS	***
	SBCo.	***	NS	NS	NS	NS	NS
	OCAC	***	***	NS	NS	NS	n/a
	CDFW	***	***	***	NS	NS	NS
	IPD	***	***	***	NS	***	***
Pup-rearing v Dispersal	LAAG	***	NS	***	*	***	***
	SBCo.	***	NS	***	NS	***	NS
	OCAC	NS	NS	***	NS	***	n/a
	CDFW	NS	NS	NS	NS	NS	NS
	IPD	***	***	NS	NS	NS	NS

Peninsula, Eastern San Gabriel Valley, and the Santa Monica Mountains Region. There also appeared to be two clusters of cities where no coyote reports were received (Mid-Cities area, and the South Bay area of Los Angeles County).

In Orange County, coyote reports were most frequently reported by the cities of Irvine and Huntington Beach. These entities, unlike others, only recorded data from one city, and not from multiple cities like other entities. In the data provided by Orange County Animal Care, the coyote reports came most frequently from the cities of Orange and Anaheim.

DISCUSSION

Coyote reports are widespread and appear to be occurring at high frequencies in many Southern California counties. The proportion of coyote reports involving conflict situations in Southern California (32%) is higher when compared with similar studies in the Denver Metropolitan Area (12.7%) (Poessel et al. 2013) and Calgary, Canada (11%) (Lukasik and Alexander 2011). The population density of both Orange and Los Angeles Counties is considerably higher than both the Denver Metropolitan Area and Calgary. Even though the population density of San Bernardino County is considerably lower, the majority of the coyote reports are coming from moderately densely populated areas. The chance of experiencing a conflict in Southern California may be higher due to a higher population of coyotes in urban areas in the region, or a higher rate of conflict-causing behaviors being exhibited in coyotes in Southern California. Others studies

have shown that coyotes that inhabit densely populated areas tend to avoid humans (Gehrt et al. 2009). The evidence from the data provided by this study does not support this, as both encounters and interactions (including coyotes biting humans) are occurring in many densely populated areas of Southern California. It has been suggested that conflict is likely to come from particular individuals in a population (Timm et al. 2004, Lukasik and Alexander 2011). Coyote reports from San Bernardino County Animal Services that were described as aggressive to humans were considerably lower than those from Los Angeles County and from Orange County. The County of San Bernardino contracts with a private animal management company that actively traps in areas where conflict events are occurring. Evidence suggests that if action is taken before pet attacks are a common problem, then further aggressive interactions can be avoided (Baker and Timm 1998). This may be why aggressive interactions are occurring at a lower rate in San Bernardino County. More information is required to accurately identify the mechanisms of lethal removal as a management option for human-coyote conflict resolution.

Temporal Patterns

The total number of coyote reports from each entity has been generally increasing since the collection of coyote reports began. This may indicate an increase in conflicts, or it may be that people are more aware of coyote conflicts in their area and are more likely to report sightings and other types of conflict. More research is needed to investigate when and why people report coyote

encounters and interactions.

Statistically significant seasonal patterns were identified in the data provided by the entities. Seasonal patterns have also been identified in previous studies examining coyote encounters and incidents (Timm et al. 2004, Gehrt et al. 2010, Lukasik and Alexander 2011, Poessel et al. 2013) and encounters only (Quinn 1995). It has been suggested that coyote pairs with pups are likely to be more aggressive when defending territories and den sites during the reproductive and pup-rearing seasons (Timm 2006). Other studies have shown that attacks on dogs by coyotes peaked in the winter (Gehrt et al. 2010, Poessel et al. 2013) or during the pup-rearing season (Lukasik and Alexander 2011). A study on the seasonality of bites in the United States between 1960 and 2006 showed that these incidents were more common during the pup-rearing season (White and Gehrt 2009). Data supplied from all entities in the present study showed that conflicts were more frequently reported during the pup-rearing season compared to the breeding season, and coyote reports were always fewer than expected in the breeding season. Although data provided by Irvine Police Department showed that conflicts were significantly higher in the dispersal season, many years showed a peak of activity in October with a tapering off of activity at the end of the dispersal period (November and December). The data provided by multiple entities suggest that conflicts are more driven by pup-rearing than actual reproduction. Whether these conflicts are food driven or territory driven is unknown and requires more research. The climate in Southern California is likely to play an important role in coyote population dynamics. Unlike Chicago, where much study has been carried out on urban coyote ecology, in California there is almost a complete absence of inclement weather during winter.

Spatial Patterns

There is evidence of coyote activity in all cities in Orange and San Bernardino Counties and in 82% of cities in Los Angeles County. This is further evidence that the coyote is a well-established urban carnivore in Southern California. Coyotes have been described as very versatile, especially in their ability to exploit human-modified environments. Their plasticity in many aspects of their ecology allows them to thrive in almost all environments that have been modified by humans (Macdonald 2004). Coyotes are living in extremely urban areas of Southern California including downtown Los Angeles (Seth Riley, National Park Service, Thousand Oaks, CA, pers. comm.). Urban coyotes commonly frequent many other densely populated and highly urbanized areas in the United States, including New York City (Berchielli 2007).

Limited spatial analysis on a gross scale of the data provided by the Agricultural Commissioner-Los Angeles County shows coyote reports (and lack thereof) clustered on a per-capita basis. The urban areas with highest incidence of reports were in parts of the county that are considered more mountainous. Research suggests that human preference for particular vegetation characteristics exist in both natural and urban environments (Ulrich 1986). It has also been suggested that wildlife and human populations may select the same appealing landscape

characteristics (Morzillo et al. 2014). Two areas of the county did not have any reports of conflict or even encounters. More research is needed to determine if landscape characteristics determine coyote distribution and what effects they have on coyote behavior, if any. This is especially true for structures such as flood control channels and rights-of-way that may play an important role in the movement of urban carnivores.

It has been acknowledged that as urban sprawl increases, so too do human-wildlife interactions (Ditchkoff et al. 2006). In a study examining urban sprawl in the United States from 1970-2010, Southern California was identified as an area that had some of the least amount of sprawl. In fact, the Los Angeles Metropolitan Area was identified as an area where sprawl has decreased more or less continually since 1970 (Lopez 2014). Little is known about the specific drivers of human-coyote conflict situations and whether competition for space between humans and coyote is causing conflict. The availability of a high concentration of anthropogenic food sources causes changes in home ranges and population density changes in mesocarnivores (Smith and Engeman 2002, Prange et al. 2004) and increases the likelihood of conflicts in bears (Peine 2001). Access to anthropogenic food has been suggested as a precursor, or contributor, to aggressive behavior by coyotes toward people (Timm et al. 2004).

Management Implications

Education efforts regarding urban coyotes should be concentrated in the early months of the year before conflicts in the pup-rearing season peak. These efforts will need to be continued into the pup-rearing season to help mitigate conflicts that are ongoing or may occur in the future. The general public should be educated on the differences between an encounter and a conflict interaction, and how to reduce the impacts or likelihood of the latter. All of the authors have often experienced the dearth of information that the general public can possess. They are aware of misinformation being provided to the public by many government and non-government entities, suggesting a necessity for a top-down education program in Southern California. This will assist agencies that extend education materials to the public to deliver these programs with accuracy and with sensitivity.

There is a need for a regional data collection effort regarding all conflicts, particularly those conflicts involving bites on humans, to help determine what is driving human-coyote conflicts in Southern California. Despite the best efforts of many agencies, mismanagement of serious human-coyote conflicts has the potential to lead to events similar to those that occurred in the Elysian Park Area in 2015, when 14 people were bitten in a relatively short time period.

Inter-entity communication and cooperation is often poorly executed in Southern California when dealing with human-wildlife conflicts. Due to the sensitive nature surrounding the conflicts themselves, or the (mis)management of the conflicts, entities do not have open lines of communications. It is the opinion of the authors that this does not serve the population well, and it can complicate and delay action in serious human-coyote conflict events.

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