

Draft

PREDATORY EFFICIENCY

AND

FORAGING HABITS

OF

THE AMERICAN KESTREL

(Falco sparverius)

AT

POINT REYES NATIONAL SEASHORE

BY

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JOHN J. SHANNON

An American Kestrel's (Falco sparverius) predatory efficiency, foraging habits and home range were studied in Marin County, California from December 18, 1981 to February 28, 1982. An analysis of predatory efficiency and prey selection is presented on the basis of numbers of prey species captured compared to the number of attempts to capture prey. A total of 758 attempts was observed; of these attempts 253 (33.3%) were successful, 505 (66.6%) were unsuccessful, and the success of 36 could not be determined. Of the 253 successful captures of prey 224 (88.5%) were invertebrates, such as grasshoppers, beetles, flies and other insects; and 29 (11.5%) were vertebrates such as birds, voles, mice and lizards. Home range of the female kestrel was approximately twice the size of the male, the females home range was approximately 2 square km while the males was approximately 1.2 square kilometers.

INTRODUCTION

An analysis of diet foraging methods and home range of Kestrels at Point Reyes National Seashore in Marin County, California, during the winter of 1981 - 1982 concentrated on a male and female with adjoining territories, with additional observations of two other males and four females. This winter was the most severe in over thirty years with unusually high precipitation and low temperatures, disrupting field observations for nine days.

The study site was located at the far North end of the seashore. It was relatively undisturbed by humans during this study. The study area consisted of flat to hilly open grasslands providing for easy observation of the Kestrels.

Since there is sexual dimorphism in the American Kestrels both in size and pelage, Cade (1955) they were easily identifiable in the field. The project encompassed approximately two and a half months with a total of sixty days in the field and approximately 480 hours of observation time including examination of traps and insect censuses.

STUDY AREA

The Point Reyes National Seashore, Tule Elk Range consists of extensive grasslands, broken by slopes, ravines and gullies with baccharis (Baccharis pilularis), Lupine (Lupinus sp), Brooms (Cytisus sp.), and Poison Oak (Rhus diversiloba). In addition, there are a small number of introduced blue gum eucalyptus trees (Eucalyptus globulus), Monterey cypress (Cupressus macrocarpa) and other plants exotic to the area. The Tule Elk range is surrounded by water on three sides. The West and North are bordered by the Pacific Ocean and the East by Tomales Bay (Figure 1). The southern end of the range is separated from the adjoining ranch by an eight-foot tall wire fence that keeps cattle from encroaching into the Elk range as well as restricting the elk. The study site extended from the elk fence to approximately 300 meters north of Windy Gap where the male's territory ended (Figure 1).

METHODS AND MATERIALS

Field observations were made with a Swift Nighthawk Mark 1 8 x 40 binoculars and a 15 power spotting scope. Observation distances ranged from 20 m to 500 m; however, most were from 75 to 250 meters.

To locate the Kestrels I hiked along ridge tops or along the ecotone between the grasslands and scrublands scanning trees, defoliated brooms, baccharis, sign post, telephone poles, and fence post. When a Kestrel was located a spotting scope was set up at a convenient location. Behavioral observations were recorded on a small cassette tape recorder. Observations were transcribed into a field notebook each evening. A stopwatch was used to quantify periods of hovering,

flyng, perching and preening.

Kestrels are primarily insectivores; but they also consume small mammals, birds and reptiles (Heintzelman 1964). One census method was used to estimate the population density of small mammals, (Otis, D.L. et. al. 1978) and two methods were used to sample the insect diversity at Point Reyes National Seashore's Tule Elk Range.

METHODS FOR SMALL MAMMAL TRAPPING

During a four-week period, 100 Sherman live traps were set up in a 200 meter square grid. Two sites were sampled, both heavily utilized by the Kestrels while foraging. Traps were checked twice per 24 hours, at dusk and at sunrise. Trapping continued for five consecutive days, Monday through Friday. The following Monday, they were reset at the second site. Each site was trapped every other week for a total of two samples per site. Two traps per grid were set up in open grasslands with the grid crossing scrubland-grassland ecotone. Traplines nine and ten were in the ecotone; the other eight traplines were in the open grassland. To establish the small mammal density and distribution between the open grasslands and scrublands, the Mark-recapture population and density estimation program developed by the Utah Cooperative Wildlife Research Unit was used.

METHODS FOR INSECT CENSUS

An insect census was conducted to determine the availability of insects in the study area. A 30 cm insect net with a 1.5 m handle was used for a total of twenty figure eight sweeps (ten from the right and ten from the left). The insect census occurred in the same location as the small mammal traplines were located. Insects captured were placed in a liter size jar containing ethyl acetate. The insects were then removed and placed in plastic bags labeled by sample site and dated. All insects were identified to order.

A second method was used to estimate grasshopper density. A 1m² frame

was randomly placed in open grasslands which were utilized by the Kestrels. The area within the frame was then carefully searched and the number of grasshoppers, if any were counted.

The insect censuses were used to determine what insect orders inhabited the area and which ones were being consumed by observations of the Kestrels themselves and the examination of their castings. The insect censuses were conducted in the open grasslands that were being utilized by the Kestrels.

METHODS USED IN LOCATING KESTREL CASTINGS

A casting consists of the indigestible parts such as hair, extoskelton, teeth, and bones, that are consumed, then compacted and regurgitated. As often as possible, the Kestrels were followed at dusk to their evening roost. The following morning after the Kestrel had departed from its roost, the ground would be examined for castings. Additionally, under four perches, two sign posts and two telephone poles, a four x four square fine-wire screen was placed around the perch to catch the castings, the vertebrate and invertebrate remains. The ~~first~~th location was the water tank on top of a hill with a pyramid-like roof. Approximately a meter from the top, a wire catch-screen was placed completely around the water tank perch site to collect vertebrate or invertebrate remains. Each morning, each perch site was examined for castings. When castings were located, they were placed in a plastic bag with the date and location, thus keeping them separate for later examination and for finding out if there were any significant differences in the contents of the male and female castings.

RESULTS

PREDATORY EFFICIENCY

The Kestrels attempted to capture prey from a perch 21% of the time and from a hovering position 79% of the time. However, no hawking (Balgooyen, 1972) was observed at any time. Of a total of 758 attempts recorded, 253 (33%) were successful, 505 (67%) were unsuccessful, and 36 were of undetermined success.

The undetermined attempts to capture prey were not calculated in the predatory efficiency portion of this study. Visual obstruction such as flora or the Kestrels completing an attempt to capture prey behind a hill or ravine resulted in the undetermined attempts.

The hunting method most commonly used by the Kestrels was hovering. Hovering was not significantly more effective than stillhunting (perching). The Kestrels conducted 579 attempts from a hovering position, of which 201 (35%) were successful and 32 attempts were undetermined. Tables 1 and 2 show the breakdown between the two different methods used by the Kestrels while hovering. Table 3 gives the combined results of both methods used by the Kestrels while hunting in a hovering position. Of the 179 attempts to capture prey from a perch, 52 were successful and four were undetermined, thus resulting in a success rate of 29%. Additionally, Table 4 gives the breakdown of hunting efficiency while the Kestrels were perched, and Table 5 gives the combined results of hovering and perched hunting methods.

TABLE 1

RESULTS OF HUNTING BY HOVERING, PLUMMETING ATTACK

MONTHS	CAPTURES	ATTEMPTS	UNKNOWN	PERCENT
DEC	1	5	3	20.0
JAN	11	59	6	18.6
FEB	17	89	10	19.1
	<u>29</u>	<u>153</u>	<u>19</u>	<u>18.9</u>

TABLE 2

RESULTS OF HUNTING BY HOVERING, FEET FIRST ATTACK

MONTHS	CAPTURES	ATTEMPTS	UNKNOWN	PERCENT
DEC	0	11	2	.0
JAN	109	248	6	43.9
FEB	63	167	5	37.3
	<u>172</u>	<u>426</u>	<u>13</u>	<u>40.3</u>

TABLE 3

COMBINED RESULTS OF TABLES 1 AND 2, HUNTING WHILE HOVERING

MONTHS	CAPTURES	ATTEMPTS	UNKNOWN	PERCENT
DEC	1	16	5	6.2
JAN	120	307	12	39.1
FEB	80	256	15	31.2
	<u>201</u>	<u>579</u>	<u>32</u>	<u>34.7</u>

TABLE 4

RESULTS OF HUNTING EFFICIENCY FROM A PERCH

MONTHS	CAPTURES	ATTEMPTS	UNKNOWN	PERCENT
DEC	19	64	1	28.6
JAN	18	58	1	31.0
FEB	15	57	2	26.3
	<u>52</u>	<u>179</u>	<u>4</u>	<u>29.1</u>

TABLE 5

COMBINED RESULTS OF HOVERING AND PERCHED HUNTING EFFICIENCY

MONTHS	CAPTURES	ATTEMPTS	UNKNOWN	PERCENT
DEC	20	80	6	25.0
JAN	138	365	13	37.8
FEB	95	313	17	30.3
	<u>253</u>	<u>758</u>	<u>36</u>	<u>33.3</u>

Hovering was the most successful means of hunting. Most of the large invertebrates and all the mammals, birds and reptiles during this study were captured during hovering. Of the 224 invertebrates captured, 172 (76.7%) were caught while the Kestrels were hovering and 52 (23.3%) occurred from a perch. Additionally, a significantly large percentage of identifiable large invertebrates were captured while the Kestrels were hovering (Table 6).

TABLE 6

A COMPARISON OF HUNTING EFFICIENCY BETWEEN HOVERING AND PERCHED
POSITION OF KESTRELS

PREY SPECIES	NUMBER CAPTURED	HOVERING	PERCHED
INVERTEBRATES			
Odonata (Dragonflies)	1	0	1
Coleoptera (Beetles)	5	3	2
Orthoptera (Grasshoppers)	53	36	17
Unidentified	165	133	32
	224	172	52
VERTEBRATES			
Microtus californicus	7	7	0
Reithrodontomyes megalotis	2	2	0
Peromyscus maniculatus	1	1	0
Zonotrichia leucophrys	1	1	0
Bird , unknown passerine	1	1	0
Gerrhonotus coeruleus	1	1	0
Unknown lizards	2	2	0
Unidentified	14	14	0
	29	29	0

PERCHED HUNTING

While the American Kestrels were perched and actively seeking prey, their perch sites varied in height from a Baccharis bush 1.2 m tall to a limb of a Monterey cypress tree 22 m above the ground. The Kestrels would always be perched on an exposed branch with no foliage that might obstruct the field of vision, or they would perch on a sign post or telephone pole. From the perch, the Kestrels would scan the terrain for potential prey by rotating or tilting their heads downward. Upon locating a prey item, the Kestrel's head "would snap into a fixed position" (Balgooyen, 1972). The Kestrel would then attempt to capture the prey. However, "if the prey is improperly oriented for attack, the hunter intently waits, frequently engaging in exaggerated head-bobbings and tail-pumping" (Balgooyen, 1972).

On three specific occasions, grasshoppers were observed moving

approximately 8 to 14 m from a perched female Kestrel. The female stopped her head movement on two occasions, looked where the grasshopper had landed, and flew to the area and landed. The Kestrel then flew back to the perch and ate the grasshopper. On the other occasion, the Kestrel observed the grasshopper land approximately 12 m from its perch. Again the head movement stopped. However, on this occasion, the Kestrel appeared to become transfixed on the grasshopper. The female Kestrel began much head-bobbing and tail pumping, often spreading her tail. This continued for 43 seconds, whereupon the Kestrel flew to the area and landed floating feet first. She remained on the ground for 11 seconds and during that time she moved about before returning to her perch with a successful capture of a grasshopper. This activity was observed often while the Kestrels hunted from a perch.

HOVERING HUNTING

When hovering, the Kestrel would have its head tilted downward and relatively stationary. When prey had been located, the Kestrel would use one of two different attack methods. The Kestrel would plummet directly downward, head first with wings near its sides when after mammals or other vertebrates or, a floating feet-first dive when after invertebrates (Roest, 1957).

During the period of observation, the Kestrels conducted 76% of their hunting activity from a hovering position. As the wind reached 5 km per hour or greater, the Kestrels would often be found hovering rather than perching. The Kestrels hunted over the open grasslands and in the ecotones between the grasslands and scrublands.

The Kestrels captured their prey with their feet and killed it with their beak. When the Kestrels land and had captured a prey item, the bird would remain on the ground for 4 to 13 seconds moving its head down to its talons and killing its prey or consuming it on the spot. While on the ground, the wings remained spread on every occasion.

The low number of captures of vertebrates could be correlated with the low population density of small mammals in the study area. Reptiles were not as abundant as small mammals possibly because of the low temperatures and high precipitation during the winter.

Most of the literature supports the conclusion that Kestrels take flying prey on the wing (Church, 1967 and Mayr, 1966). However, during this study on one occasion, a White Crown Sparrow (Zonotrichia leucophrys), was captured while perched. The male sparrow was perched on top of a broom singing. The female Kestrel was hovering approximately 15 - 20 meters above ground level and 20 to 30 meters from the sparrow. The Kestrel went into a head-first plummeting dive with wings near its sides. When approximately 3 to 5 m from its chosen prey, it spread its wings in a somewhat exaggerated U and had talons down and open. It struck the sparrow while it remained perched. It appeared as if the Kestrel landed where the sparrow had been perched for approximately 6 seconds. There was much head activity by the Kestrel around its talons. The Kestrel then flew with much difficulty to its perch, approximately 100 m away. On the second occasion, the Kestrel again plummeted head first; however a capture was not observed.

INSECT SWEEP CENSUS

Of the ten areas that were randomly chosen that the kestrels frequently most often, the insect sweep included the orders Coleoptera (Ladybird Beetle), Orthoptera (Grasshopper), Diptera (Flies), and Hemiptera (Stink Bug), (Table 7). A large number of the insects caught in this census were also found in the casting and seen during observations.

The second insect census method was to obtain some quantitative information on grasshopper population density in the areas the Kestrels were utilizing. The results of the grasshopper census in Area 1 and Area 2 are presented in Table 8.

TABLE 7

INSECT CENSUS RESULTS TAKEN AT POINT REYES
(SEE MAP FOR AREAS WHERE CENSUS WAS TAKEN)

AREA	ORDER OF INSECTS	FREQUENCY OF INSECTS
1	Araneida	17
	Coleoptera	13
	Orthoptera	7
	Diptera	6
	Coccinellidae	4
2	Araneida	11
	Orthoptera	8
	Coleoptera	5
	Coccinellidae	5
	Diptera	1
	Hymenoptera	1

TABLE 8

FREQUENCY OF GRASSHOPPERS FOUND PER 1m² FRAME
RANDOMLY PLACED IN OPEN GRASSLANDS

AREA	GRASSHOPPERS PER FRAME	FREQUENCY OF OCCURENCES	DENSITY
1	0	28	.37 per 1m ²
	1	7	
	2	5	
2	0	26	.43 per 1m ²
	1	8	
	2	5	
	3	1	

SMALL MAMMAL CENSUS

The overall capture of all small mammals was low with a net result of 26 during the first week in Area 1 and 34 in the second week of trapping. Area 2's results were somewhat higher with the first week of trapping resulting in

the capturing of 41 animals and the second week 32 animals being captured. Table 9 has the number of animals caught and population density estimate was obtained by the computer program.

TABLE 9

POPULATION DENSITY OF SMALL MAMMALS AT POINT REYES

AREA	SPECIES	NUMBER CAPTURED	POPULATION DENSITY/HA
1			
WEEK 1	Peromyscus maniculatus	12	13
	Reithrodontomys megalotis	8	12
	Microtus californicus	5	2
	Sorex ornatus	<u>1</u>	0
	Total	26	
WEEK 2	Peromyscus maniculatus	18	23
	Reithrodontomys megalotis	9	13
	Microtus californicus	<u>7</u>	4
	Total	34	
2			
WEEK 1	Peromyscus maniculatus	28	41
	Reithrodontomys megalotis	12	14
	Sorex ornatus	<u>1</u>	0
	Total	41	
WEEK 2	Peromyscus maniculatus	17	23
	Reithrodontomys megalotis	11	12
	Microtus californicus	<u>4</u>	4
	Total	32	

EXAMINATION OF KESTREL CASTINGS

Of the 32 castings that were collected from the Kestrel's perches, undamaged castings total 26. The lengths of the castings varied from 16mm to 38mm, and the widths ranged from 10mm to 14mm. The average was 24.4 mm x 12.4 mm, thus finding approximately what Davis (1960 and Elliss (1946) found in their examination of Kestrel castings.

The examinations of the castings revealed grasshoppers were the prey species utilized the most (Table 10). Also beetles were taken in large abundance and Microtus californicus was the mammal most frequently taken.

TABLE 10

CONTENTS OF KESTREL CASTINGS

SEX	CASTINGS	INSECT ORDER	# INSECTS OF EACH ORDER	MAMMALS	# OF MAMMALS
Male	14	Orthoptera	38	M. californicus	3
		Coccinellidae (Ladybird)	13	R. megalotus	2
		Coleoptera	11	Sorex	1
		Diptera	2		
		Dermaptera	1		
FEMALE	18	Orthoptera	53	M. californicus	7
		Coccinellidae	17	R. megalotus	3
		Coleoptera	12	P. maniculatus	

HABITAT SEPARATION

Territoriality, habitat separation and differences in sex ratios of American Kestrels wintering in different locations have been reported by other researcher (Roest 1957, Koplin 1973). During this study, there were six females and three males located in the Tule Elk Range. A rather distinct difference in habitat selection by the Kestrels was observed during this project. The female Kestrel had more open habitat than the male. The male also used somewhat smaller patches of grassland and relatively more scrubland than the female (Figure 1).

During this study, the male Kestrel encroached on the female's territory on a least seven different occasions. On six occasions the female gave chase and issued several loud "kleeing" calls as she pursued the male. On one occasion the male was perched in the female's territory while she was hovering approximately 500 m away. The female moved to a telephone pole approximately 125 m from the male. She remained perched for approximately ten minutes whereupon she flew directly towards the male. The male then left his perch and landed on the far

northern portion of a barn, approximately 40 m away but still in the females' territory. The female remained perched for about three minutes whereupon she flew to the far southern end of the barn and landed. Both Kestrels remained perched for an additional seven minutes, one or both periodically letting forth with several "Klees". The female then flew to the male and displaced him, pursuing the male out of her territory. Brown and Wilson (1956) state that habitat segregation of wintering Kestrels by sex is a form of character displacement and reduces intraspecific competition for food resources.

DISCUSSION

During the period of observation, the Kestrels hunting methods included hovering (76%) and still hunting (33%). The Kestrels captured their prey on the ground or near it (Bond 1936). This method was also observed at Point Reyes. The Kestrels take different types of prey species more or less in proportion to their abundance. At Point Reyes' Tule Elk Range, invertebrates constituted 89% of the prey items captured and consumed; mammals and other vertebrate made up the other 11%. Of the invertebrates taken, grasshoppers were heavily utilized, constituting 90% of the known invertebrates captured. Microtus californicus was the small mammal that was captured most often of the known vertebrate, it was taken 47% of the time. The low capture of vertebrates, especially small mammals could be correlated with the low population of the animals and the severe winter that occurred at Point Reyes in 1982. The Kestrels hunted throughout the day. This may be correlated with insect activity. Invertebrates and reptiles are poikilothermous, and remain active most of the day if insolation and comfort temperatures are high.

Balgooyen (1972) and Callopy (1973) found that the Kestrels conducted most of their attempts to capture prey from a perch and were significantly more successful than hovering attempts to capture prey. Possibly because of the relatively low number of perches available and because the area which the Kestrels were

utilizing was situated near the ocean which provided a substantial wind factor, the Kestrels found it more advantageous to conduct their hunting while hovering rather than perching. Hovering seemed to give the Kestrels more territory to scan and find prey than a perch position offered. Additionally, Balgooyen (1972) found that the Kestrels at Sagehen did not hover unless the wind velocity was 5 km per hour or greater. During this study at Point Reyes, there rarely was a day that the wind velocity was not greater than 5 km per hour. Therefore, the Kestrels in this area hunted while hovering substantially more than they did from a perch.

As Roest (1957) reported, The Kestrels plummet in a head-first dive when after mammals and feet-first when attempting to capture insects. These same methods were observed during this study. Additionally, Roest (1957) found that the majority of capture attempts by the Kestrels was a floating feet-first downward attack, which was observed in this study. Of the 579 total attempts to capture prey while hovering, 201 attempts (34.7%) were successful. However, the Kestrels were significantly more successful while hovering and attempting to capture prey with the feet-first dive. The floating-downward attack method had a success rate of 40.3% or 172 successful captures out of 426 attempts. The plummeting head-first for small mammals or other vertebrate had a success rate of 18.9%, that is 29 captures out of 153 attempts. This study did not reveal any plummeting head-first attempts for prey from a perch; only the feet-first floating method was used.

Hovering allows for greater utilization of an area; that is, more territory can be viewed while the Kestrels are hovering than when they are perched. Hovering always was accompanied by the wind, and the Kestrels would always orient into the wind. Otherwise, the energy expenditures would have become too costly (Balgooyen, 1972). It was noted during the observations of the Kestrels while they were hovering that the wing movement, tail width, and body angle corresponded with the wind velocity. When the wind exceeded approximately 10 km per hour, the

Kestrel's tail was not spread wide, (only approximately a third to a half of its potential width). Additionally, there was little wind movement, and the Kestrels were almost horizontal to the ground. When the wind was less than 10 km per hour, or they were in an area that was not exposed to a great amount of wind, the tail was spread to the maximum, and it would often spread in a V shape. Its body appeared to be tilted upwards slightly thus possibly to provide better lift.

The insect sweep census was conducted twice during this project with rather poor results on both occasions. This could possibly be attributed to the high precipitation that occurred this year at Point Reyes^e. Additional surveys in the following years during the same period of time could shed light on the low population of insects. The insect census did correlate with the findings in the castings and what the Kestrels were observed utilizing.

Along with the poor insect census results the small mammal population was low. The low number of animals captured indicates the small mammals in the area are at a low in their three and four-year annual cycle. Additionally, the results of this years winter could have had an effect in reducing the number of small mammals.

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SUMMARY

Future observations on hunting efficiency of the Kestrels at Point Reyes' Tule Elk Range is needed to indicate whether or not the Kestrels would take more

small mammals in relation to insects when the small mammal population density is higher. Balgooyen (1972) found that almost 70% of the successful capture of prey at Sagehen involved vertebrates. A comparison should be made between the Kestrels at Point Reyes and other seashore areas to compare the time spent hunting by hovering and still hunting. Balgooyen (1972) found that approximately 97% of the hunting activities of Kestrels at Sagehen occurred from a perch, and Collopy (1973) found that the Kestrels hunted from a perch approximately 81% of the time.

Kestrels hunted by two methods of hovering and from a perch. They captured their prey on or near the ground usually in the open grasslands and along ecotones. The Kestrels at Point Reyes apparently take prey species more or less in proportion to their abundance. Invertebrates constituted about 89% of their diet while vertebrates constituted approximately 11%. The Kestrels success rate varied from perch hunting 29% to 34.7% while hovering. The two methods that the Kestrels used while hovering, plummeting was the least successful with a capture rate of 18.9% and the feet-first floating attack was successful 40.3% of the time.

Habitat separation of the male and female was rather distinct with the females territory approximately twice the size of the males, 2 square km for the female and 1.2 for the male. Habitat separation could be to lower intraspecific competition between the Kestrels.

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