Predicting Lift Off Using a Proposed Factor Analysis:
Is It Possible to Predict When Swainson's Hawks Will Kettle and Depart?
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DRAFT: 2 July 2021

Figure 1. Courtesy of Hal Cohen

Swainson's Hawks (along with turkey vultures[1]) migrate during the spring time from Central and South America into south western Canada stretching all the way into Alaska. Generally, they arrive in the Borrego Valley, California in late February and can still be seen into early April where they settle overnight in the fields and trees around

[1] Ravens also mix in with these hawks and turkey vultures, but do not migrate, according to Hal Cohen.

the town. Known colloquially as the grasshopper or locust hawk, they forage for insects, especially Sphinx moth caterpillars at this site.[2] Leaving their night roost in the early to mid-morning to continue their journey northward, the hawks seek out thermal updrafts and form a kettle (aka a caldron or a boil).[3] This characteristic "wheeling and circling in the air"[4] flight behavior reminds some of the steam rising from a tea kettle; hence, the name. At some point, a hawk (aka leader) decides that its elevation is high enough and they begin peeling off towards the north (i.e., Coyote Canyon). Several researchers including the ESS Group[5] have theorized that kettling behavior by birds is a form of avian communication.

Indeed, one may begin to wonder if birds have developed a system of "pressure-pattern flying?"[6] That's a researchable question.

Objectives and Variables

Despite studies since 1832 showing that "ornithologists have been interested in the relation between weather conditions and spring bird migration in our temperate latitudes,"[7] the research literature remains meagre[8] and therefore, it is unclear how to know when they are likely to kettle and later depart. Hence, the objective of this study

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[2] "White-Lined Sphinx Moth Caterpillars" at http://jvrichardsonjr.net/birds/Moth.htm (accessed 8 April 2021).

[3] The origin of this term is unclear, although in 2007 David Gessner asserted that the Pennsylvania lowland known as "der Kessel" or the Kettle near Hawk Mountain is the source; see *his Soaring with Fidel: An Osprey Odyssey from Cape Cod to Cuba and Beyond* (Beacon Press, 2007). See also, "Fun Fact" at https://www.thespruce.com/glossary-definition-kettle-386843 (accessed 6 April 2021).

[4] "Kettle (birds)" at https://en.wikipedia.org/wiki/Kettle_(birds) (accessed 6 April 2021).

[5] See "Tern Observations Near Monomoy Island, August 28-31, 2006: Nantucket Sound, Massachusetts" https://web.archive.org/web/20080925110043/http://www.mms.gov/offshore/PDFs/CWFiles/TernReport12-8-06.pdf.

[6] H. Landsberg, "Bird Migration and Pressure Patterns," *Science* 108 (1948): 709 at https://science.sciencemag.org/content/108/2817/708.2 (accessed 8 April 2021).

[7] A. M. Bagg et al., "Barometric Pressure-Patterns and Spring Bird Migration," *Wilson Bulletin* 62 (no. 1, March 1950): 6.

[8] The notable exception is Paul Kerlinger's 375-page *Flight Strategies of Migrating Hawks* (Chicago: University of Chicago Press, 1989), but even the 1990 *Science* book review commented upon his "slender base of data."

is to identify, describe, and weight the relative contribution of each variable to the prediction of their departure time. Obviously, there are these dependent variables: thermal updraft (TU), kettle formation (KF), rate of climb to altitude (RCA), and departure time (DT). Furthermore, there are several independent variables which could be influencing these outcomes.

We can consider the relative loading of many potential variables which have been proposed that could explain when these a bird senses that it is time to depart. The following list also attempts to operationalize the various independent variables--

Atmospheric conditions (AC_1):

1) Air density (using a lb./cu. ft. calculator)
2) Air temperature (measured either in Fahrenheit or Celsius)
    a. "The main migration is only relatively dependent on a rise in temperature. Severe cold waves stop migration short."[9]
    b. Rising/falling air temperature (nominal level data)
3) Barometric or atmospheric pressure in a given area (measured as ATM Hg)
    a. Officially measured at the Jacqueline Cochran Regional Airport (aka KTRM or the Thermal Airport, 28 miles from Borrego Springs) or Borrego Valley Airport (at 520 feet above sea level, BXS is 3 miles east of Borrego Springs)
    b. Falling pressure causes birds to eat more[10]
    c. High pressure is generally cloudless
    d. Rising rather than falling[11]
4) Cloud cover (nominal: presence/absence or amount, low or high) or type (cumulus or cumulonimbus clouds)
    a. "Low pressure is generally accompanied by clouds and rain"[12]

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[9] Ibid., p. 7.

[10] See "Birds Predict Weather Change and Adjust Behaviour by Reading Barometric Pressure," at https://phys.org/news/2013-11-birds-weather-adjust-behaviour-barometric.html (accessed 5 April 2021).

[11] Thomas Alerstam, "Analysis and a Theory of Visible Bird Migration," *OIKOS* 30 (no. 2, October 1978): 273-349 at https://www.jstor.org/stable/3543483?seq=1#metadata_info_tab_contents (accessed 6 April 2021).

[12] Bagg (1950), p. 8.

   b. Low clouds versus higher clouds[13]
   c. Low number of clouds is correlated
5) Dew point (meaning the "temperature to which air must be cooled to become saturated with water vapor")
   a. Related to relative humidity
6) USFS Donald Haines Lower Atmosphere Stability Index[14] (1988) ranges from 2-6
   a. Based on the temperature and dew point above the ground
7) Relative humidity (in percentage terms)
   a. The temperature when the relative humidity is at 100% is the dew point
8) Wind gradient
   a. It is of "primary importance to explain the variation in migratory intensity"
   b. Speed (MPH or measured on the Beaufort scale)
      i. Speed is less at ground level and faster higher up
   c. Could be simplified as presence/absence (nominal level data)
9) Wind direction (measured by an aviation quality airport wind sock)
   a. Favorable direction (i.e., southernly?)
   b. Tail wind (reduced effort)

A) Ground Conditions (GC_2):

1) Height of Sun above Horizon
   a. "Sufficiently high"[15] by mid-morning
2) Viable food source
   a. Presence/absence[16]
3) Elevation

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[13] M. Panuccio et al., "Migrating Birds Avoid Flying Through Fog and Low Clouds," *International Journal of Biometeorology* 63 (no. 2, February 2019) at https://pubmed.ncbi.nlm.nih.gov/30687905/ (accessed 5 April 2021).

[14] USFS-WFAS, Wildland Fire Assessment System at https://www.wfas.net/index.php/haines-index-fire-potential--danger-34 and "What is the Haines Index?" at https://www.fs.fed.us/pnw/airfire/haines/whatishaines.html (accessed 5 April 2021).

[15] Julie Craves, "What Makes a Group of Hawks a 'Kettle,'" at Birdwatching—see https://www.birdwatchingdaily.com/beginners/birding-faq/what-makes-a-group-of-hawks-a-kettle/ (accessed 6 April 2021).

[16] Cohen to Richardson via email, 15 April 2021.

   a. Compared to atmospheric conditions in the kettle
4) Ground temperature
   a. Using a non-contact infrared thermometer (e.g., Performance Tool W89720)
5) Precipitation (inches)
   a. Presence/absence (nominal level data)
   b. Negative correlation with rain[17]
6) Visibility (in miles)[18]
   a. Positive rather than negative[19]

An actual scientific study of the dependent variables (TU, KF, RCA, or DT) and the two independent variables (AC_1 and GC_2) would determine the relative contribution of each of these variables in predicting the outcome. In short, though, one could theorize that the presence of thermal uplifts, high and rising temperature, southernly wind intensity, and rising barometric pressure, [20] low but rising humidity all greatly contribute to a Swainson's Hawks ability to depart sooner rather than later in the morning.

So, now we just need to obtain extra-mural funding and we will know definitively when to get out of bed in the morning to see them depart!

Acknowledgments

The author wishes to recognize one individual as well as a group who helped his thinking about this subject: Hal Cohen (Raptorhal3@gmail.com to sign up for the Hawk ALERTS), former professor of biology of College of DuPage in Glen Ellyn, Illinois and the coordinator and founder of the citizen-scientist organization called the Borrego Valley Hawkwatch (BVHW founded 2003). Be sure to "like" the Friends of the Swainson's Hawk at https://www.facebook.com/Friends-of-the-Swainsons-Hawk-136271987605/ as well as The Hawk Blog (Borregohawkwatch.blogspot.com). And, I

[17] Alerstam (1978), p. 273.

[18] "Meteorological Visibility" at https://www.iala-aism.org/wiki/dictionary/index.php/Meteorological_Visibility(accessed 6 April 2021).

[19] Alerstam (1978), p. 273.

[20] May be accurate for nocturnal bird migration (an alternate hypothesis: low and falling pressure); see, however, Ian C. T. Nisbet and William H. Drury Jr., "Short-term Effects of Weather on Bird Migration: A Field Study Using Multivariate Statistics," *Animal Behaviour* 16 (no. 4, November 1968): 496-530.

enjoyed the informal morning and evening discussions, especially Randy Lenon[21] with those "hawkaholic" volunteers and other visitors between 17 March and 31 March 2021.

Note: The BVHW data (which includes Wind Speed, Wind Direction, Temperature, Cloud Cover, Visibility, Flight Direction, and Height of Flight since 2003) is reported to the Hawk Migration Association of North America using the WRS Protocol and Forms at https://www.hmana.org/winter-raptor-survey/. The extant data is publicly available at Hawkcount.org by selecting monthly, scrolling down to Borrego Valley, click site, then year, daily and month. According to Hal Cohen, "a fairly good example of data" comes from 14 March 2019: "Wind: 1 on scale; Wind Direction: NW; Clouds: 0; Temperature: 11.5; Flight Direction: NW; Time of Lift Off: 6:20am; Streaming: 6:38am; Streaming from Ellis Farm; Hawks were first observed at 6:20am beginning to kettle up. Around 20 Sw[ainson]'s flew from the Date Farm to join a large kettle forming over Elis Farm. By 6:38am they began to stream NW."

Updated: 2 July 2021; Last Revised: 6 April 2021; **Created**: 5 April 2021.

[21] In an email to Hal Cohen, he wrote "I would hypothesize that the 4 most determinative factors affecting hawk launch are: 1) Wind; 2) Atmospheric Stability; 3) Solar Intensity (as a proxy for evaluating thermal development/convection); and 4) Temperature" based on his firefighting experience and hawk watching in Panama.