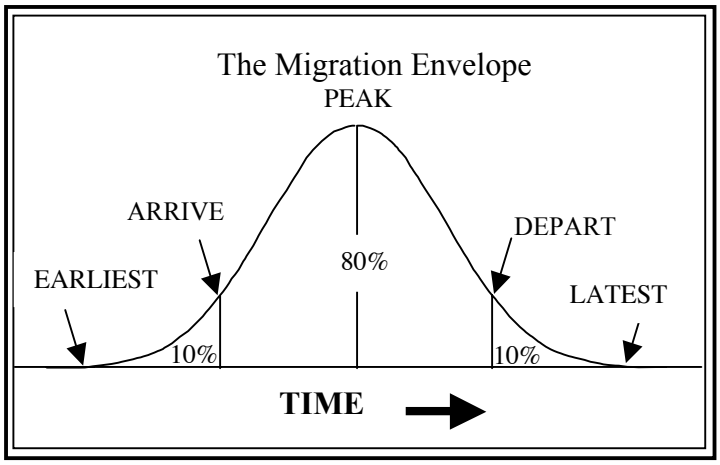
SPECIES ACCOUNTS: Migration Envelopes

Migration envelopes consist of an array of dates that define an imaginary curve representing a migration. The envelopes are based on the premise that migration can be described by a statistical distribution, perhaps similar to the familiar "bell-shaped" curve. That is, a plot of number of individuals versus time (observation dates), provides a pattern similar to the curve shown on the right.



Migration envelopes list the critical dates that define the migration curve for each species. Each envelope is calculated so that 80% of the individuals pass through between the ARRIVE and DEPART dates. Thus, about 10% of the migrants pass prior to the ARRIVE date and 10% leave after the DEPART date. Midpoint of the envelope marks the migration PEAK. The EARLIEST and LATE dates are unique, so the year of observation is also included.

The Arrive Date

Arrival dates have been treated in a variety of fashions by different authors. Early authors (e.g., E.R. Ford, 1956) simply provided an arrival date without explanation of its origin. Others have listed average first arrival dates. In her treatment of hummingbird migration, Williamson (2001) lists the "average spring arrival dates." All of these approaches have limitations, as the dates are linked to observer effort (i.e., how many individuals were out looking during the appropriate time). The arrival date (ARRIVE) used in this treatment is the date that denotes 10% of the migration envelope. The 10% value was selected as it represents the date, based on personal experience, on which a field observer has a reasonable expectation of seeing the bird. A 5% mark on the envelope compares more closely with average first arrival dates, but this is not a date on which field observers are likely to encounter the bird.

The migration envelope works best for species that are strictly migrants (i.e., species that are not also summer or winter residents). Records associated with residents tend to mask those of migrants.

If sufficient data are available spring and fall envelopes are generated for each of the three tiers (see Worm-eating Warbler example below). If fewer than 30 records exist the ARRIVE and DEPART dates are considered unreliable and are not listed; the PEAK date is also omitted if fewer than ten records exist.

An analogy with a picket fence might help clarify the migration envelopes. Each lath in the fence represents a single day and lath height reflects the total number of individuals recorded that day. To de-emphasize the effects of multiple individuals per observation, each record was added using the mathematical relation: $1 + \log_e$(number of individuals). After the computer reads all records, the fence area is calculated and the date marking the first 10% of the fence area is taken as the average ARRIVE date. Midpoint of the date fence is taken as the migration PEAK, and DEPART marks the passage of 90% of the records.

Example: Migration Envelope for Worm-eating Warbler						
Migration Envelopes						
Spring						
	Earliest	**Arrive**	**Peak**	**Depart**	**Latest**	**Records**
North	20-Apr-1992	27-Apr	11-May	28-May	Sum. Res.	92
Central	17-Apr-1947	23-Apr	8-May	30-May	Sum. Res.	77
South	15-Apr-1976	21-Apr	9-May	3-Jun	Sum. Res.	117
Fall						
	Earliest	**Arrive**	**Peak**	**Depart**	**Latest**	**Records**
North	Sum. Res.	---	20-Aug	---	19-Sep-1992	12
Central	Sum. Res.	---	---	---	25-Oct-1985	9
South	Sum. Res.	26-Jul	24-Aug	20-Sep	7-Oct-1950	32

Consider the central tier in the above Worm-eating Warbler (which happens to be a summer resident) Migration Envelope example. In spring the all-time "EARLIEST" arrival date is 17 April 1947. The "ARRIVE" date is 23 April, which marks the 10% point of the spring flight. The "PEAK" occurs 8 May and the "DEPART" date is 30 May. As this species is a summer resident the "LATEST" date has no significance and is omitted. Thus, in spring 80% of the central Indiana Worm-eating Warblers pass through between 23 April and 30 May. Some 77 records (the column headed "Records") were incorporated into the calculation of this envelope. The fall envelope for the central tier has only 9 records; consequently, the ARRIVE, PEAK, and DEPART dates are not listed.

Migration envelopes allow one to trace the average movement of the migration through the state. Consider the following spring envelopes for the Ruby-throated Hummingbird.

Example: Migration Envelope for Ruby-throated Hummingbird						
Spring						
	Earliest	**Arrive**	**Peak**	**Depart**	**Latest**	**Records**
North	10-Apr-2004	07-May	18-May	03-Jun	Sum. Res.	474
Central	05-Apr-2004	26-Apr	10-May	01-Jun	Sum. Res.	145
South	02-Apr-2004	21-Apr	9-May	24-May	Sum. Res.	111

The "Arrive" column indicates that hummingbirds arrive in the southern tier 21 April and in the northern tier on 7 May, a 16-day separation. Dates in the "Peak" column suggest a nine-day separation. Thus, spring Ruby-throated Hummingbirds take between nine and 16 days to migrate the length of Indiana, i.e., an average of 13-22 miles per day.

References Cited

Ford, E. R. (1956) *Birds of the Chicago Region*, Special Publ. No. 12 Chicago Acad. Sci, 117 pp.

Williamson, S.L. (2001) *Hummingbirds of North America*, Houghton Mifflin Co., Boston, 265pp.