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# The Kinglets of Delaware

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## Introduction

Kinglets are very small (~7g) pale green, insect-eating passerines which derive their common name from the crown of colorful feathers present in the males and in some species, also the females. There are two kinglets in North America, and both can be found in Delaware from September through April (Hess et al. 2000). The two species are superficially similar in their appearance although closer examination reveals several key differences (Fig. 1; Thompson et al. 2005). The Ruby-crowned Kinglet (*Corthylio calendula*) has a plain face with an incomplete white eye ring and a bright red crown, although this is only present in males and is usually concealed. The Golden-crowned Kinglet

(*Regulus satrapa*) has a dusky malar stripe, a pale eye stripe, and a black cap surmounted by a golden crown that is present in both sexes. The crown of the male also contains several bright red feathers though these can be difficult to see. Although they were formerly placed in the same genus (*Regulus*), DNA analysis found that the Golden-crowned Kinglet is more closely related to the Eurasian Goldcrest (*Regulus regulus*) than it is to the Ruby-crowned Kinglet, which was subsequently placed in its own genus (Swanson et al. 2021).

The two kinglets have an extensive and mostly overlapping breeding distribution which spans the entire continent. However, the breeding range of ruby-crowns is much further north, with most of their eastern popula-



**Figure 1.** Golden-crowned Kinglet on the left and Ruby-crowned Kinglet on the right. Photos by Michael Moore.

tion occurring above the Canadian border. The breeding range of Golden-crowned Kinglets also includes most of Canada but extends much further south into the Midwest and Pennsylvania, where they are year-round residents (Swanson et al. 2020, 2021). Both species usually breed in coniferous forests but can be found in a variety of habitats at other times of the year. Several authors have commented that the two species occupy different ecological niches during the winter, with golden-crowns being more likely to occur in conifers than ruby-crowns (Lepthien and Bock 1976, Swanson et al. 2020).

The fact that the two species are broadly similar with respect to size and diet yet show some differences in their breeding range and perhaps non-breeding habitat presents an interesting comparison of the factors affecting their occurrence in Delaware. Both kinglets can be found state-wide during migration and winter and are regularly recorded during the Audubon Christmas Bird Counts (hereafter ‘CBCs’) (Hess et al. 2000). We therefore used the CBC data to answer four basic questions about the number and distribution of both species of kinglet in Delaware during the winter: 1) Which species of kinglet is most common in winter? 2) Is there a correlation between the number of each species seen each winter? 3) Is the number of kinglets seen each winter correlated with the average temperature, so that more are seen in warmer winters? 4) Does the ratio of Golden-crowned Kinglets to Ruby-crowned Kinglets increase southwards because the proportion of conifer trees increases?

## Methods

We retrieved the number of both kinglets recorded on each CBC between 1971 and 2020 from the Audubon website ([www.netapp.audubon.org/cbcobservation](http://www.netapp.audubon.org/cbcobservation)). At the time of writing (July 2022) the data from the 2021 CBC was not available and so the period we selected represents the last fifty years of data. These data are drawn from seven count circles spread throughout the state (Table 1). CBCs have been run in some of these circles for much longer (see Stewart et al. 2018 for dates) but we decided to restrict our analyses to the last fifty years, partly because this is a convenient round number but also because coverage was uneven in the earliest years. Also, the number of CBC circles in

**Table 1.** The average number of Golden-crowned and Ruby-crowned Kinglets (mean  $\pm$  standard error) seen in 7 count circles during the 1971–2020 CBCs, together with the ratio of Golden-crowned to Ruby-crowned and the estimated % of the tree cover made up of conifers. Count circles are listed from the northernmost to the southernmost.

	Golden-crowned	Ruby-crowned	# Golden/#Ruby	% Conifers
Wilmington	28.0 $\pm$ 2.9	6.3 $\pm$ 0.7	4.4	<5
Middletown	11.6 $\pm$ 1.1	6.8 $\pm$ 0.9	1.7	<5
Bombay Hook	16.9 $\pm$ 1.9	10.4 $\pm$ 1.1	1.6	10-20
Milford	33.9 $\pm$ 3.5	7.6 $\pm$ 1.5	4.5	50-60
Cape Henlopen - Prime Hook	34.8 $\pm$ 4.4	7.6 $\pm$ 1.3	4.6	25
Seaford - Nanticoke	56.0 $\pm$ 5.3	5.5 $\pm$ 0.9	10.2	65
Rehoboth	33.8 $\pm$ 3.3	7.3 $\pm$ 1.3	4.6	10
Average	30.7	7.4	4.5	

Delaware increased from three to five in the mid-1960s with the addition of the popular Cape Henlopen-Prime Hook and Wilmington counts, and so the last fifty years encompasses a period when the statewide coverage became extensive. We downloaded the raw data on the number of both species recorded on each count as well as the number of birds per party hour, which is a standardized measure that controls for the number of observers and the number of hours they spent in the field. However, for both species the number of birds observed and the number of birds per party hour were very highly correlated ( $r = 0.93$   $n = 50$   $P < 0.001$  for Golden-crowned Kinglets, and  $r = 0.97$   $n = 50$   $P < 0.001$  for Ruby-crowned Kinglets). We therefore used the number of birds observed as the metric for the analysis, graphs, and table as it is easier for the reader to follow.

Each CBC is held on a different date across a two-week period, with the earliest taking place in the third week of December and the latest in the first week of January. Furthermore, the exact date of each count varies between years because most are scheduled for weekends and no longer take place on Christmas Day. However, calculating the temperature experienced during each count, or perhaps in the week(s) leading

up to it, was beyond the scope of this article. We therefore estimated how cold it was during each CBC as the average temperature that December. We downloaded the average daily temperature between 1 December and 31 December from 1971 to 2020 from the Dover station of Weather Underground ([www.weatherunderground.com](http://www.weatherunderground.com)). We calculated the average December temperature in each year as the mean of the daily averages. We obtained the total precipitation in the same period from the Dover station of the National Weather Service ([www.weather.gov](http://www.weather.gov)). No data were available for three Decembers (2005, 2012 and 2020). We assumed that weather data from Dover represented conditions throughout Delaware as it is in the middle of the state.

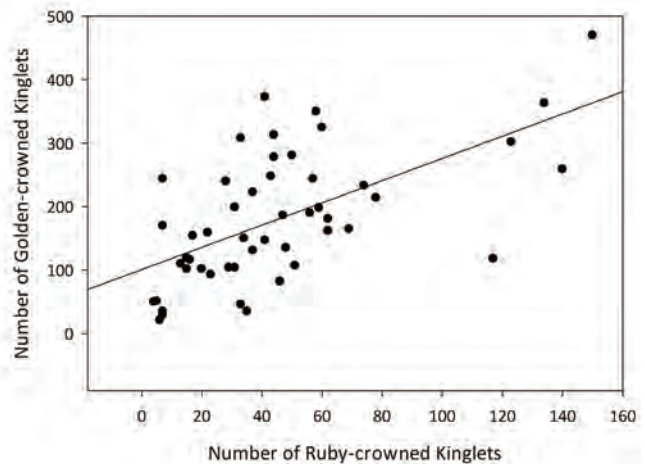
We used banding data on kinglets captured at two sites in the Red Clay Valley to provide additional insights into kinglet movements. Banding was conducted 1–2 times per week at Ashland Nature Center (Hockessin, Delaware) and Bucktoe Creek Preserve (Kennett Square, Pennsylvania) from April through November 2015 to 2021. Birds were captured using four to six 12-meter-long mist nets erected in areas of mixed habitat, primarily deciduous woodland with stands of pines adjacent to meadows dominated by goldenrod (*Solidago* sp.).

## Results

Both species of kinglet were observed on every one of the last fifty CBCs.

1) The most numerous of the two kinglets was the Golden-crowned, which was approximately four times as common as the Ruby-crowned (average number of Golden-crowned Kinglets = 179, range 21–470; average number of Ruby-crowned Kinglets = 45, range 4–150; Table 1). The total number of Golden-crowned Kinglets seen in the last fifty years was also significantly more variable than the number of Ruby-crowned Kinglets (F-test for comparison of variance,  $F_{49,49} = 8.4$   $p < 0.001$ ).

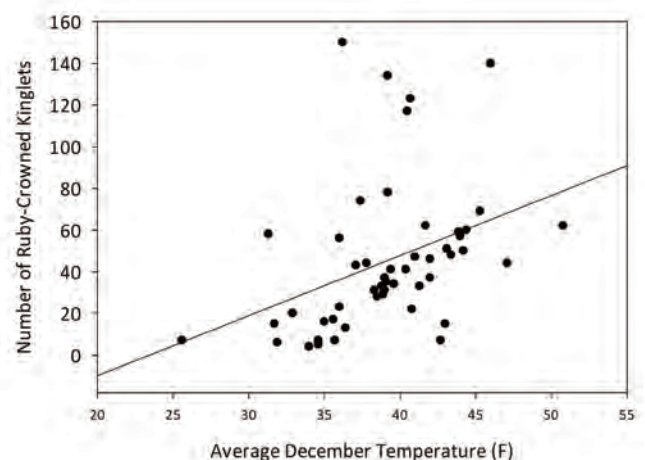
2) There was a highly significant positive correlation between the number of each species seen on the last fifty CBCs ( $r = 0.61$   $n = 50$   $p < 0.001$ , Figure 1). The peak number of both species occurred in the same year (2017, with 470 Golden-crowns and 150 Ruby-crowns). However, the lowest number of Golden-crowned King-



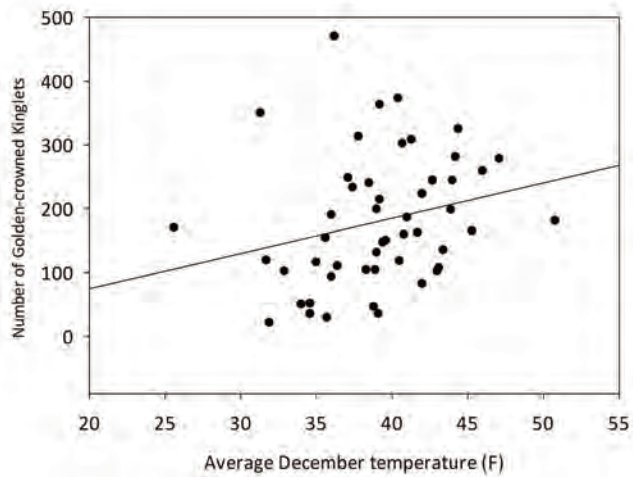
**Figure 1.** The number of Golden-crowned Kinglets observed on the 1971–2020 CBCs in relation to the number of Ruby-crowned Kinglets.

lets was in 1976 ( $n = 21$ ) while the lowest number of Ruby-crowned was in 1985 ( $n = 4$ ).

3) The average December temperature in the last fifty years was 39°F and ranged from a low of 26°F (1989) to a high of 51°F (2015). The number of Ruby-crowned Kinglets seen on the last fifty CBCs was significantly positively correlated with the average December temperature ( $r = 0.37$   $n = 50$   $p < 0.01$ , Figure 2a). However, the correlation between the number of Golden-crowned Kinglets and the average December temperature was only a non-significant trend ( $r = 0.25$   $n = 50$   $p = 0.08$ , Figure 2b). The number of Ruby-crowned Kinglets was not related to total December precipitation ( $r = -0.02$   $n = 50$   $p = 0.98$ , Figure 2c).



**Figure 2a.** The number of Ruby-crowned Kinglets observed on the 1971–2020 CBCs in relation to average December temperature.



**Figure 2b.** The number of Golden-crowned Kinglets observed on the 1971–2020 CBCs in relation to average December temperature.

= 47  $P = 0.89$ ) nor was the number of Golden-crowned Kinglets ( $r = 0.14$   $n = 47$   $p = 0.33$ ).

4) The highest number of Golden-crowned Kinglets was recorded on the Seaford-Nanticoke count while the lowest was recorded on the Middletown count (Table 1). The highest number of Ruby-crowned Kinglets was recorded on the Bombay Hook count while the lowest was recorded on the Seaford-Nanticoke count. The ratio of Golden-crowned to Ruby-crowned Kinglets was highest on the Seaford-Nanticoke count (10.2 to 1) and lowest on the Bombay Hook count (1.6 to 1). The ratio of Golden-crowned to Ruby-crowned Kinglets recorded in each of the seven count circles was not related to the estimated percentage of coniferous trees (Spearman's rank  $r = 0.60$   $n = 7$   $P = 0.12$ , Figure 3).

#### Banding data

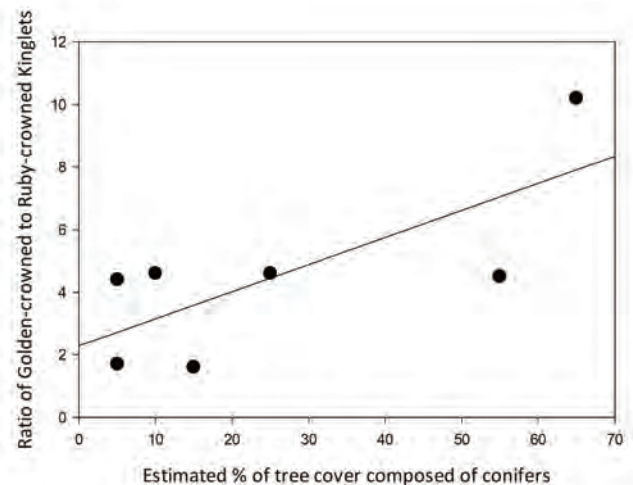
Ruby-crowned Kinglets (128) were banded in the Red Clay Valley from 2015–2021 compared with only 7 Golden-crowned Kinglets. The first Ruby-crowned Kinglet was banded on 24 September, after which the number banded increased up to a clear peak around the final week of October. Only 2 of the 128 Ruby-crowns were recaptured. The first was recaptured the same day it was banded and the second was recaptured 3 days later in the same location. The first Golden-crowned Kinglets were banded on 15 October (2 birds) then 5 more sporadically through November with no clear peak. None were recaptured. No kinglets of either species were banded in spring.

## Discussion

We used data from the last fifty Christmas Bird Counts to answer four simple questions about the number and distribution of the two species of kinglet present in Delaware during the winter.

We found that Golden-crowned Kinglets are approximately four times as numerous as Ruby-crowned Kinglets and that their numbers are significantly more variable between years. We also found that the number of Golden-crowned Kinglets seen each winter was strongly positively correlated with the number of Ruby-crowned Kinglets. In other words, if many golden-crowns were present there would also be many ruby-crowns, but if there were few golden-crowns there would also be few ruby-crowns. This suggests that the number of each species present each winter is governed by the same factor or factors. Given that both species are very small, it seems intuitive that the average winter temperature is likely to be a key factor since small birds have a large surface area to volume ratio and will lose body heat rapidly. In support of this, a continent-wide analysis found positive correlations between the regional density of both kinglets and January temperature (Leptien and Bock 1976).

The data suggest that average winter temperature does influence kinglet numbers on Delaware CBCs, at least in one species. The number of Ruby-crowned Kinglets recorded was positively related to average Decem-



**Figure 3.** The ratio of Golden-crowned to Ruby-crowned Kinglets in relation to the percentage tree cover composed of conifers in 7 CBC count circles.

ber temperature, with few in cold winters and more in warmer winters. The number of Golden-crowned Kinglets seen each winter was also positively related to average December temperature although it was only a non-significant trend. The lowest number of ruby-crowns ( $n = 4$ ) was in a winter that was among the coldest (1985, average =  $34^{\circ}\text{F}$ ), and the lowest number of golden-crowns ( $n = 21$ ) was also in a winter that was among the coldest (1976, average =  $31.9^{\circ}\text{F}$ ). Interestingly, the peak number of both species occurred in the same winter (2017) when 150 ruby-crowns and 470 golden-crowns were seen. However, the average temperature that December was only a few degrees above freezing ( $36.2^{\circ}\text{F}$ ). Lepthien and Bock (1976) found that the regional winter density of Golden-crowned Kinglets was more strongly correlated with total winter precipitation more than average temperature, though we found no relationships between winter precipitation and numbers of either species.

The fact that the number of ruby-crowns was more strongly related to average December temperature than was the number of golden-crowns was somewhat surprising. Our banding data showed that golden-crowns are slightly lighter, although the difference is not significant (Golden-crowned average weight = 6.2g, range 5.5–6.9  $n = 7$ , Ruby-crowned average weight = 6.5g, range 5.4–8  $n = 122$ ,  $t = 1.02$   $df = 127$   $p = 0.31$ ). Since they are smaller, one would expect golden-crown numbers to be more strongly affected by temperature. However, Swanson et al. (2020) cite unpublished experimental data that this species can tolerate colder temperatures than Ruby-crowned Kinglets. This may explain why the wintering distribution of Golden-crowned Kinglets ranges far into New England and the Midwest and even lower Canada, while that of Ruby-crowned Kinglets is south and east of the Appalachian Mountains (based on a summary of eBird records from December to February ([www.eBird.org](http://www.eBird.org))).

It is difficult to know whether a scarcity of kinglets in Delaware during freezing winters is because the remainder succumbed to the cold conditions, or they migrated further south to warmer states. The migration patterns of both species are poorly understood (Swanson et al. 2020, 2021), partly because the proportion of banded kinglets that are recaptured is extremely small. Since 1960, 479,460 Ruby-crowns have been

banded in the United States of which only 1156 (= 0.24%) have been encountered (recaptured or found dead). Since 1960, 236,959 Golden-crowned Kinglets have been banded of which only 297 have been encountered (= 0.13%) ([www.usgs.gov/labs/bird-banding-laboratory](http://www.usgs.gov/labs/bird-banding-laboratory)). Banding data from two stations we operated in the Red Clay Valley suggest that the peak in fall migration of kinglets is the last week of October (which is very similar to the peak timing reported at a prior banding station in northern Delaware (Hess et al. 2000)). Almost none of these birds were recaptured, suggesting that they are still moving south well into late fall. The weather conditions they experience during this period may affect how many remain in Delaware into the winter and how many continue to migrate. It is also possible that the numbers of one or both species are more strongly affected by winter temperatures to our north, and when these are very low large numbers of kinglets flood south into Delaware. Placing radio-transmitters on kinglets to track their regional movements using the Motus network ([www.Motus.org](http://www.Motus.org)) would help answer these questions but this is challenging on such tiny birds.

Finally, we did not find a clear southward increase in the proportion of Golden-crowned Kinglets, and only weak evidence that they were associated with conifers. It was striking that the highest number of Golden-crowned Kinglets occurred on the Seaford count (as was also noted by Hess et al. 2000), since over half of the trees in this circle are conifers. However, the Milford count also has a high proportion of conifers yet the number of golden-crowns recorded was not particularly high. Furthermore, most of the count compilers did not associate Golden-crowned Kinglets with conifers. Several commented that they did not usually find kinglets in trees of any type but were more likely to find them in the brushy understory below trees or in tall-grass meadows. Understanding the differences in kinglet numbers between and within count circles clearly requires a closer examination of their microhabitat.

There may also be a detection bias between the two species which varies based on whether they are located by sight or sound. For example, Ruby-crowned Kinglets have been reported to be solitary birds, whereas Golden-crowned Kinglets tend to occur in flocks (Thompson

et al. 2005) which might make them easier to find. Several count compilers commented that they often encountered golden-crowns mixed in with flocks of other small birds, which might also make them easier to find. However, Golden-crowned Kinglets have a high-pitched call note which is harder to detect than the loud, harsh 't-dit' call of Ruby-crowned Kinglets, especially for participants with hearing issues.

We encourage participants on future Delaware CBCs to ponder the differences in habitat and ecology between these two tiny but intriguing birds.

## Acknowledgements

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