

RECENT INCREASE IN THE YELLOW-BILLED MAGPIE POPULATION IN SACRAMENTO AND ITS POSSIBLE CAUSES

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ABSTRACT: The Yellow-billed Magpie (*Pica nuttalli*) declined substantially throughout its range after the West Nile virus arrived in California in the 2000s, and neither development of disease resistance nor population recovery have been reported. After surveying 8 occupied sites in 2020 and 22 occupied sites in 2021 for a study of the magpie's habitat use in urban Sacramento, I continued surveying 15 urban parks in 2022 and 2023 to evaluate population trends over 4 years. The Sacramento magpie population increased consistently by 3–7% per year, suggesting a localized recovery. Since the extent of foraging habitat remained stable, other factors, possibly including development of resistance to the virus (as seen in other species of birds), may be promoting a population increase. These results, however, are local and relatively short term. More work is needed to determine if resistance is developing and to understand longer-term population and disease trends in other parts of the Yellow-billed Magpie's range.

The 2003 arrival of West Nile virus (WNV) in California caused a substantial and rapid decline in the population of the California endemic Yellow-billed Magpie (*Pica nuttalli*; Airola et al. 2007, Koenig et al. 2007, Crosbie et al. 2008, Smallwood and Nakamoto 2009, Kilpatrick and Wheeler 2019). Unlike other WNV-affected species, the magpie has not been reported to have developed widespread immunity to the disease (Crosbie et al. 2008).

Christmas Bird Count data summarized through 2019 showed that the Yellow-billed Magpie population in the Central Valley declined rapidly from 2003 to 2006 and more gradually from 2007 to 2016 (Pandolfino 2013, 2017). A slight increase may have followed from 2017 to 2019 (Pandolfino 2020), but the population remained at <20% of its pre-virus level and recently has appeared to fluctuate with annual levels of WNV activity (Pandolfino 2013, 2017, 2020). Range-wide Breeding Bird Survey data showed a continuous decline through 2017 (Kilpatrick and Wheeler 2019), and eBird data show a decline through 2021 (Fink et al. 2022). The North American Bird Conservation Initiative (2022) identified the Yellow-billed Magpie as one of 70 “tipping point species” whose population in the U. S. has declined by >50% since 1980 and could lose another half or more of its population in the next 50 years.

Surveys of three roost sites around Sacramento shortly after the arrival of WNV found the magpie had been eliminated at two and had declined substantially at a third and that the decline was associated with reports of “dozens” of magpies found dead near roost sites (Crosbie et al. 2008). Dead Yellow-billed Magpies found soon after WNV's arrival had the highest rate of positivity for the virus among 50 species tested (Wheeler et al. 2009). Continuing monitoring has documented WNV's persistence in the Sacramento region (Snyder et al. 2020) and continued magpie mortality from the disease (<https://westnile.ca.gov/>; <https://maps.vectorsurv.org/arbo/>).

Surveys for the Sacramento County Breeding Bird Atlas showed a decline in rural areas since the 1980s but persistence in urbanized areas from 2016

to 2020 (Pandolfino et al. 2021). In the 1980s, magpies were documented breeding in 82 (62%) of 132 atlas blocks, but in the 2010s in only 33 (25%) of blocks. Sixteen (20%) of 82 blocks where breeding was confirmed in the early period were urbanized, while in the second period 14 (42%) of the 33 confirmed blocks were urbanized (E. Pandolfino pers. comm.). In 2020 and 2021 the sizable remnant Yellow-billed Magpie colonies in riverine parks in the Sacramento metropolitan area were reproducing successfully and the population appeared to be stable (Airola et al. 2021). Numbers in various Sacramento locales were closely associated with the amount of foraging habitat near rivers and creeks, suggesting that colony sizes there were determined by habitat availability rather than WNV.

Additional information is needed on the status of the remnant Yellow-billed Magpie population in Sacramento to ascertain whether it is declining, stabilized, or recovering (Airola et al. 2021, Koenig et al. 2022). To address this need, in 2022 and 2023 I resurveyed the urban riverine parks that Airola et al. (2021) studied in 2020 and 2021.

The incidence of WNV typically peaks in late summer and early fall and is elevated in years with above-average precipitation and following a year of below-average precipitation (Landesman et al. 2007, Soverow et al. 2009, Snyder et al. 2020). Therefore, I evaluated whether changes in Sacramento's magpie population in these four years were associated with rainfall in the same year or in the prior year.

METHODS

In 2020, I surveyed Yellow-billed Magpie nesting colonies at eight parks, semi-rural areas, vacant lands, and adjacent residential areas within the city of Sacramento and surrounding Sacramento County. In 2021, I surveyed 43 sites, including 22 that supported magpies (Airola et al. 2021). In 2022, I surveyed 13 of the previously occupied sites, including the eight 2020 sites and five of the other 2021 sites. In 2023, I added two additional occupied sites to the 13 surveyed in 2022, both of which had been surveyed in 2021, for a total of 15 occupied colony sites. I selected the 2022 and 2023 colony sites to sample various colony sizes. Thus a core group of eight sites were surveyed in four consecutive years (2020–2023), five additional sites were surveyed in three consecutive years (2021–2023), and two others were surveyed in 2021 and 2023.

As described by Airola et al. (2021), all study sites were within larger urban parks and surrounding residential neighborhoods that contained large trees suitable for nesting and extensive areas (4–20 ha) of managed turf or mowed or grazed annual grassland. All sites were within 0.5 km of rivers or creeks, which is known to be important to magpie occupancy (Airola et al. 2021).

I conducted all surveys (including those in 2020 and 2021; Airola et al. 2021) and surveyed the same areas at each site during each year. I estimated magpie populations at survey sites by counting the number of active nests and multiplying by two, which Airola et al. (2021) found to be more reliable and efficient than direct counts of birds. Active nests were easily detected because of their large size, high location, and presence usually within deciduous trees. I identified a nest as an active magpie nest (versus a remnant from the previous

year or another species' nest) if it had a stick "dome" over it or adults were attending or building it. I completed at least two nest-count surveys at each site. In 2022, the first surveys extended from 24 January to 5 February, the second from 15 February to 15 March, during nest building but prior to the leafing out of deciduous trees, which obstructs nests' visibility.

In 2023 the weather was cool and wet, which delayed leaf-out of deciduous trees and magpies' nesting. Therefore, I conducted the first surveys that year from February 26 to March 3 and second surveys (and in some cases a third survey) as late as March 26. Flooding at Discovery Park interrupted surveys after 5 March in 2023, so I rechecked nests there on 19 April after waters had receded but before trees had leafed out. I searched for dead magpies during all surveys.

I calculated annual rates of change in numbers for each site, for the total numbers at the eight sites that were surveyed over four years (2000–2023), and for the total numbers at the 13 sites that were surveyed over three years (2021–2023). Two sites, Howe/Santa Anita parks and Bellevue Park, were surveyed only in 2021 and 2023, so I estimated the annual change at these sites as the average of the change from 2021 to 2023.

I summarized annual rainfall at the Sacramento WB City station (<http://stratus.water.ca.gov/dynamicapp/QueryWY?Stations=scr&SensorNums=2&End=2022-03-14&span=7+years>). To evaluate potential connections among rainfall, WNV, and magpie populations, I compared annual population changes to the deviation in annual (October–April) rainfall from the long-term average, in both the same year and the previous year. Because of the study's limited number of years, I did not analyze the data statistically but rather assessed whether the direction and magnitude of population changes were in concordance with the amounts and changes in rainfall, and thus potentially WNV activity.

RESULTS

Population Trend

All Sacramento survey sites that supported Yellow-billed Magpie nesting colonies in 2020 and 2021 were still occupied in 2022 and 2023. Numbers at the eight sites surveyed in all four years increased by 17% over that period, equivalent to a rate of 6% per year (Table 1). Numbers at the 13 sites surveyed in 2021, 2022, and 2023 increased by 3% in 2022 and then by 7% in 2023 (Table 1). Numbers at the two sites surveyed in 2021 and 2023 increased by 13%, equivalent to an average annual rate of 6%. The average annual change in numbers at individual sites over the 3- or 4-year periods ranged from –17% to +34% (Table 1). Numbers increased at 10 of 15 sites and declined at five. At three of these five sites, however, the decline was by only two birds (i.e., one nesting pair), and the colonies at two of these sites were small (3 and 4 pairs). I found no dead magpies.

Rainfall and Population Levels

Rainfall was 60% above average during the 2019 water year prior to the 2020 survey and then varied from 42% to 135% of the long-term average in

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TABLE 1 Number of Nesting Yellow-billed Magpies and Rates of Change in Sacramento, 2020–2023

Colony site	Year				Change				Annual average
	2020	2021	2022	2023	2020–21	2021–22	2022–23	2021–23	
Discovery Park	174	172	192	198	–1%	12%	3%		5%
East Park Rd.	84	88	78	82	5%	–11%	5%		–0.5%
Howe/Santa Anita parks		68		82				20%	10%
Larchmont Park		52	50	42		–4%	–16%		–10%
Renfree Field	36	42	48	54	17%	14%	13%		14%
William B. Pond	30	30	30	40	0%	0%	33%		11%
Township Station 9		26	30	46		15%	53%		34%
Hagan Community Park		28	28	20		0%	–29%		–14%
Ancil Hoffman Park	26	24	26	30	–8%	8%	15%		5%
Oak Meadow Park	22	16	22	24		38%	9%		6%
Phoenix Park	20	26	22	28	30%	–15%	27%		14%
Bellevue Park		18		28				55%	28%
Horseman’s Club	10	14	10	14	40%	–29%	40%		17%
Ashton Park/ Estates Dr.		8	8	6		0%	–25%		–13%
Riviera East Park		6	4	4		–33%	0%		–17%
8-site total	402	412	428	470	3%	4%	10%		6%
13-site total		532	548	588		3%	7%		5%
15-site total		618		698				13%	6%

subsequent years (Table 2). If wetter than average years result in an increased mosquito population and WNV activity, which then reduced the magpie population in the subsequent year, the magpie population should have been depressed in 2020 because of above average rainfall in 2019. It then should have increased through 2022 as the previous year’s rainfall remained below average and then declined or remained stable in 2023 after precipitation fell below average in 2022. The magpie population increased from 2020 to 2022, but then continued to do so in 2023 despite average rainfall the preceding year. Therefore, the hypothesis that the previous year’s rainfall affected WNV

TABLE 2 Rainfall in Portion of Water Year (October–March) before and during the Yellow-billed Magpie’s Breeding Season, 2019–2023, and Expected Population Responses

Breeding season year	Rainfall (cm)	% of average	Effect predicted from rainfall		Observed population response
			In previous year	In current year	
2019	66.3	158%			
2020	21.4	51%	Low population	High population	
2021	20.1	48%	Increase	Increase	Increase
2022	44.2	105%	Increase	No change	Increase
2023	65.2	155%	No change	Decrease	Increase

and the magpie population was only weakly supported (i.e., consistent with predictions in two of three years).

If the rainfall from October to March prior to and during the breeding season affected WNV levels and magpie mortality rates in the same season, the population should have increased in 2021 due to low rainfall in 2020, remained the same in 2022 with average rainfall, and decreased in 2023 during a wetter year. The annual increase in the magpie population from 2020 to 2023 was consistent with these predictions in only one of three years (Table 2).

DISCUSSION

Population Status

Although localized, this study found some of the first suggestions of recovery of a Yellow-billed Magpie population since the WNV-induced decline in the 2000s. The 2020–2023 survey results document a slow but steady increase in the Sacramento's Yellow-billed Magpie population by 3–6% per year over three years and an increase at 10 of 15 sampled colony sites.

The increase of the Sacramento population is striking, contrasting with a Central Valley-wide decline of >80% from the mid-2000s to 2019 on Christmas Bird Counts (Pandolfino 2020) and a substantial decline in adjacent rural areas documented in the Sacramento Breeding Bird Atlas (Pandolfino et al. 2021). The general pattern among WNV-affected birds identified by Kilpatrick and Wheeler (2019) was steeper declines in urban areas, contrary to these results.

Surveys at Discovery Park on 19 April 2019 after flood waters receded confirmed the 5 March count of 99 nests (i.e., 198 birds). I could not, however, verify whether all nests observed on 19 April were still active or whether the temporary flooding of nearly all adjacent foraging habitat prevented establishment of additional nests or caused nest abandonment or failure.

Potential Causes for the Population Increase

On the basis of Christmas Bird Count data, Pandolfino (2020) suggested that the Central Valley magpie population experienced “small recoveries during low WNV years, followed by renewed declines in response to subsequent virus outbreaks.” The continued increase in the Sacramento urban population from 2020 to 2023 is inconsistent with the fluctuations he identified for the Central Valley population as a whole through 2019, when our studies began. This time period, however, is short and the increases were modest and localized (although in a population that reached nearly 700 individuals).

Airola et al. (2021) suggested that the strong correlation between population sizes at urban Sacramento parks near rivers and streams and the extent of low herbaceous habitat for foraging suggests that magpie numbers there were limited by available foraging habitat rather than by WNV. Yet a steady increase from 2020 to 2023, while habitat in this urban area remained largely unchanged, is inconsistent with a simple habitat-based determinant of population size.

Intensive monitoring and control of WNV to protect human health in the Sacramento region, and perhaps other similar urban areas, could be providing

incidental protection to magpie populations (Airola et al. 2021). Previously, Smallwood and Nakamoto (2009) attributed the slower decline in the magpie population within the city of Davis, Yolo County, than in nearby rural areas, to more intensive WNV-abatement efforts there. Levels of mosquito control and its effectiveness in reducing WNV incidence are difficult to quantify, but long-established control efforts in Sacramento do not appear to have intensified in recent years, in a way that might have triggered a magpie-population increase. Nor has WNV incidence in humans decreased in California, at least from 2004 to 2017 (Snyder et al. 2021).

The increase in Sacramento's Yellow-billed Magpie population from 2020 to 2023 suggests while the extent of foraging habitat determines the species' relative abundance at various sites, other factors are contributing to the overall population increase. The consistent annual increase despite rainfall varying from 42 to 160% of normal (Table 2) suggests that either rainfall variations are not tied to WNV levels, possibly because of mosquito-control efforts, or that WNV is not regulating the magpie population, perhaps because of development of resistance. The recent increase is consistent with the hypothesis that population growth may be resulting from gradual acquisition of resistance to WNV, as seen in other affected species (Kilpatrick and Wheeler 2019, Pandolfino 2020). The possibility that the population has increased only temporarily, however, cannot be dismissed.

Testing of live magpies in 2006 detected WNV antibodies in only one of 21 individuals sampled, indicating that the species had not then developed widespread resistance (Crosbie et al. 2008). The lack of recovery through 2019 in the Central Valley also suggests that widespread resistance had not developed (Pandolfino 2020). No antibody testing of live birds, however, has been reported since 2006. Testing of magpies for WNV antibodies would be useful in determining whether the Sacramento population, and perhaps other populations, are beginning to develop resistance.

Of the possible explanations for the Yellow-billed Magpie's stability in Sacramento, I am able to discount only the effect of rainfall variation as a substantial factor. The availability of foraging habitat, WNV surveillance and treatment, and possibly the development of disease resistance all could be contributing to population increases in Sacramento. Clarifying the responsible factors and verifying whether the increase continues, will require additional data.

Population Assessment and Conservation Needs

The increase in the remnant Yellow-billed Magpie population of urban Sacramento is encouraging, but available evidence through 2019 shows that the broader Central Valley population has been substantially depleted without showing any signs of recovery (Kilpatrick and Wheeler 2019, Pandolfino 2020). Neither has the status of the population in other urban areas been determined. Given the relatively ease of surveying for the species through nest counts (Airola et al. 2021), additional effort to track other urban and rural populations is warranted. The relatively healthy Yellow-billed Magpie population in Sacramento and perhaps other cities warrants habitat protection and management, and continued suppression of West Nile virus, to encourage further development of disease resistance (Kilpatrick and Wheeler

2019). Such urban areas may serve as a reservoir to repopulate areas where the species has been depleted.

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