Factors shaping body condition of chicks in a resident Yellow-legged Gull *Larus michahellis* population

Juan Arizaga*, Asier Aldalur & Alfredo Herrero

Department of Ornithology, Aranzadi Sciences Society, Zorroagagaina 11, 20014 Donostia, SPAIN *Corresponding author, e-mail: jarizaga@aranzadi.eus

Arizaga J., Aldalur A., Herrero A. 2024. Factors shaping body condition of chicks in a resident Yellow-legged Gull *Larus michahellis* population. Acta Ornithol. 59: 85–92 DOI 10.3161/00016454AO2024.59.2.001

Abstract. The provision of sufficient food to chicks is of key relevance not only for their growth, but also for the accumulation of a certain degree of reserves that can be allocated to face potential food shortages in the future. The Yellow-legged Gull *Larus michahellis* is the most abundant gull in the southwestern Palearctic but the species is showing a very fast demographic decline directly attributed to food shortage, in particular linked to the closure of open-air landfills. Theory predicts that such a strong and sudden limitation in food availability should have a strong impact on chicks, but studies dealing with how body condition of Yellow-legged Gull chicks varies annually, and is also influenced by other environmental factors including weather, is still barely known. Using a data set of thousands of Yellow-legged Gull chicks ringed in three colony sites from Gipuzkoa (N Spain) during 14 years, we aimed to test for the effect of different environmental stressors to evaluate the relative importance of the colony, year or weather in spring on chick body condition. Body condition (particularly in relation to colony, together with a random year-colony effect. Prevailing meteorological conditions (particularly, temperature) also seemed to, more moderately, explain the pattern of this variation. We conclude that the main environmental driver explaining our results may be food availability, but weather may also have an impact.

Key words: anthropogenic food, Basque coast, breeding, climate change, seabirds

Received — Aug. 2024, accepted — Dec. 2024

INTRODUCTION

The provision of sufficient food to chicks is of key relevance not only for their growth, but also for the accumulation of a certain degree of reserves that can be allocated to face potential food shortages in the future (Braasch et al. 2009, Arizaga et al. 2015). Thus, fatten chicks have a better survival prospect in the case of adverse weather in spring, for instance due to rainfall anomalies (Rodríguez & Bustamante 2003). Similarly, post-fledging survival is higher with increasing fledging mass (Greńo et al. 2008, Arizaga et al. 2015), and the physical status of the chicks can have long-term consequences on recruitment and, overall, population dynamics through carryover effects (Cam & Aubry 2011, Monticelli & Ramos 2012). To some extent, chicks body condition can be used as a surrogate of the quality of breeding season, and understanding the role of factors shaping body condition is, therefore, important in population

dynamics contexts. This is also important to estimate the effects of climate change on reproduction.

Many gull (genus Larus) species have shown very fast population growth rates since the last quarter of the 20th Century (Raven & Coulson 1997, Morais et al. 1998, Vidal et al. 1998, Oro & Martinez-Abrain 2007). Such exceptional increase contrasts with the general decline observed for many seabirds worldwide (BirdLife International 2021). To a large extent gulls have benefited from exploiting food subsidies of human origin found offshore, along the coast and inland (Isaksson et al. 2016, Ramírez et al. 2020), a behavior allowing them to be more competitive than many other strictly marine seabirds. Thus, gulls forage on fish discards (obtained offshore) (Zorrozua et al. 2023), but also organic waste from dumps, fishing harbors or urban areas (Ramos et al. 2009b, Cama et al. 2012, Arizaga et al. 2013, Camphuysen et al. 2015, Méndez et al. 2020). The progressive

closure/management change of several of these artificial food subsidies, however, is giving rise to a new scenario where gulls would be forced to return to more 'natural' environments, adopting foraging strategies linked to potentially natural food sources (Payo-Payo et al. 2015, Delgado et al. 2021b).

Gulls are long-lived species which, under food shortage scenarios, sacrifice their actual reproductive output in favor of future reproduction (Stearns 1992), with adults prioritizing their own body condition prior to their offspring needs (Erikstad et al. 1998). A decrease in prey availability during the breeding season is expected to be passed over to chicks, which will then reduce their amount of fuel stores, growth rate and/or survival. Even though population size of seabirds depends more on adult survival than on reproduction, it is demonstrated that a poor breeding success can lead to population declines as well (Sandvik et al. 2012, Reiertsen 2013). Thus, annual variation in body condition could be partly explained by the same amount of variation in the availability of key feeding sources.

Together with food, prevailing meteorological conditions can also have a very high impact on reproduction, either directly (cold and humidity can increase the energy demands and compromise chicks' growth and survival) or indirectly (e.g., adults can reduce their foraging efficacy under adverse weather conditions) (Christensen-Dalsgaard et al. 2018b, Zorrozua et al. 2020b). The assessment of weather effects on chicks is of high importance to know how weather pattern predicted for the next decades may impact the reproductive output of birds (Christensen-Dalsgaard et al. 2018a).

The Yellow-legged Gull L. michahellis is the most abundant gull in the southwestern Palearctic (Olsen & Larson 2004). Currently, however, the species is showing a very fast demographic decline in several areas where it was very abundant until recent times (Arcos et al. 2022). Depending on regions, the decline can even be higher than 80% in less than 20 years (Arizaga et al. 2022). As mentioned above for gulls in general, the decline of the Yellow-legged Gull is directly attributed to a food shortage scenario, in particular linked to the closure of open-air landfills (Payo-Payo et al. 2015, Delgado et al. 2021b). Theory predicts that such a strong and sudden limitation in food availability should have a strong impact on chicks (Stearns 1992). In such a context, it is important to assess to what extent a deteriorating environmental

scenario, with a progressively increasing number of closed landfills, is also reflected in a progressively worsening average body condition in chicks. Moreover, how Yellow-legged Gull chicks body condition varies annually in relation to other environmental factors including weather, is still largely unknown. Using a data set over 3,000 Yellow-legged Gull chicks ringed in their colonies during 14 years, we aimed to test for the effect of different environmental stressors to evaluate the relative importance of the colony, year or weather in spring on chicks body condition.

MATERIAL AND METHODS

Sampling area and data collection

This study was carried out in three close-by Yellow-legged Gull colonies along the coast of the southeastern part of the Bay of Biscay (province of Gipuzkoa, Basque Country, N Spain), from west to east: Getaria (43°18'N 02°12'W), Santa Clara (43°19'N 01°59'W) and Ulia (43°20'N 01°57'W). Colony sizes were approximately 145, 100 and 850 breeding pairs, respectively (last census 2021), comprising most of the Yellow-legged Gull population in Gipuzkoa (Arizaga et al. 2022). The maximum inter-colony distance was of 20 km. Trophic ecology studies have shown that the colony of Getaria has a higher consumption of marine prey than the other two colonies, which in summer depend more on landfills, probably also urban waste and terrestrial prey (such as earthworms) as well (Arizaga et al. 2018, Zorrozua et al. 2020a,c).

Most chicks were ringed at the age of 20–30 days (Jordi & Arizaga 2016) during 14 consecutive seasons (2007–2020) in late June (Arizaga et al. 2020). They were ringed with individually identified metal rings (Aranzadi ringing scheme, www.ring.eus) and a Darvic ring with an alphanumeric code (Fernández et al. 2017). Ethics approval was not required and ringing was done with the licenses provided by the Gipuzkoa Administration. Chicks were weighed at ringing (with a Pesola balance, 20 g accuracy) and one tarsus was measured (with a digital calliper, providing an accuracy of 0.01 mm, though real accuracy should be of ca. 0.5 mm; J. Arizaga, pers. obs.).

Meteorological data (accumulated precipitation, mean of the daily mean and minimum temperature; for details see Appendix 1) were obtained from the Igeldo meteorological station, located 3 km west from the Santa Clara colony (source: Spanish Agency of Meteorology, AEMET). Hence, we had a single value per month and year for each variable.

Statistical approach

First, we obtained an index of body condition, which in our case was calculated from regressing body mass on tarsus length (this last used as a surrogate of body size). A log-linear function fitted to the data better than a linear function (Akaike values: log-linear, AIC = 35957.6; linear, AIC = 35990.8). Therefore, we used the residual values of the log-linear function of body mass on tarsus length to obtain a body condition surrogate (Fig. 1). Hereafter, we call this variable BC.

We fitted General Linear Mixed Models (GLMM) to test to what extent BC varied in relation to colony, year (this latter considered as a continuous variable to estimate temporal trends), and in relation to prevailing meteorological conditions in spring. We used for that the package 'lme4' (Bates et al. 2014) for R (R Core Team 2023). Before this, we considered a number of control factors or covariates which were fixed in all the models. Thus, we controlled BC for the age of the bird, here assessed with tarsus length (Jordi & Arizaga 2016). In addition, even if every single chick was measured and weighed only once to get its BC, all chicks in a colony and year are affected by the same set of external stressors (meteorological conditions, temporal availability of the key trophic sources, disturbances, etc.). Therefore, it can be expected that BC of chicks in a year and colony are more similar than BC of chicks from other years and colonies. The models should consider this lack of independence, e.g. by including a random part with coefficients for each year-colony. Given that we had some gaps within the data set (no data for a few colonies in given years), we

$\begin{array}{c} 1000 \\ 1000 \\ 0 \\ 1000$

Fig. 1. Relationship between body weight and tarsus length of Yellow-legged Gull chicks, and the fitted logistic regression line.

introduced a combined colony-year factor as random component rather than a colony|year random effect. So, all tested models kept this random part, together with tarsus length as covariate.

We considered rainfall (rain) and the mean of the minimum daily temperature (temp) in May (late incubation, hatching) or June (chicks growing period) (Arizaga et al. 2012), noted in the models as rain_m, rain_j, temp_m or temp_j. We used the monthly means of daily minimum temperature, rather than daily mean, because minimum temperatures would be a better proxy of the existence of cold days, which potentially would have a higher impact on BC. The correlation between the monthly means of daily mean and minimum temperature were from high to very high (May: $R^2 = 0.94$; June: $R^2 = 0.68$).

To select models, we fitted a global model. Next, we used the 'dredge' function of the MuMIn package (Barton 2014), that runs all the possible nested combinations and ranks the models in relation to their small sample size-corrected Akaike value (AICc) (Burnham & Anderson 1998). All models were run in the software R (R Core Team 2023).

RESULTS

We used a data set with 3033 chicks with their body mass and tarsus length measured (Getaria — N = 584, Santa Clara — N = 633, Ulia — N = 1816). The main statistics of the data set were (for details see also Table 1): mean body mass of the chicks when they were ringed: 628.7 g (range: 180– 1080 g); mean tarsus length: 59.4 mm (range: 34.4– 72.8 mm).

Of all models, the one considering an effect of the colony, year, temp_m and temp_j on BC was the most-supported one (Table 2). Models considering an effect of rain in June (rain_j) were also well supported. Models considering only an effect of colony, year or both, as well as the null one, were much less supported (Table 2).

The top-ranked model was found to explain 20.8% of all the variance in the data, where the fixed variables explained a 4.2% ($R_m^2 = 0.042$), and the random one, a 16.6% ($R_c^2 = 0.166$; see also for further details Appendix 2). This last means that BC varied annually within each colony, supporting a yearly effect on BC. According to the top-ranked model (Table 3), chicks from Getaria showed a significantly better BC than chicks from the other two colonies (Fig. 2).

Colony	Sample size	Body mass (g)	Tarsus length (mm)
Getaria	584	638.0 (200–1080)	58.5 (34.4–70.2)
Santa Clara	633	639.6 (260–1000)	59.8 (42.8–71.8)
Ulia	1816	621.6 (180–1040)	59.6 (38.0-72.8)
Total	3033	628.7 (180–1080)	59.4 (34.4–72.8)

Table 1. Main descriptive statistics (mean, and range in brackets) of the body mass and tarsus length of Yellow-ledged Gull chicks ringed in three breeding colonies from Gipuzkoa.

In addition, we detected a negative, but nonsignificant effect, of tarsus length on BC. Similarly, the year and temperature did not have a significant effect on BC. However, it must acknowledged that the models including meteorological variables were higher-ranked, and in the topranked one the effect of both temp_m and temp_j was truly close to p = 0.05, so the effect of temperature on BC cannot be ignored.

DISCUSSION

The variance associated to body condition (BC) of Yellow-legged Gull chicks was better explained by a random year-colony effect (yearly variations on BC, within each colony, fitting overall a random distribution), together with a colony effect and by the prevailing meteorological conditions (temperature) in spring, than by a linear effect (trend) of year. These results suggest that factors shaping BC were likely in part linked to food availability (due to the strong colony- and colony-year-associated effect), since we found in previous studies that the diet of this Yellow-legged Gull population varies substantially both among years (Zorrozua et al. 2020a) and in relation to colony (Arizaga et al. 2013). Yellow-legged Gulls adapt their diet to the existence of nearby main feeding sources,

especially during breeding period (Egunez et al. 2017, Zorrozua et al. 2020c). As a consequence, even nearby colonies can depend on very different trophic resources, from fish/marine prev to landfills or urban waste (Ramos et al. 2006, Moreno et al. 2009, Carmona et al. 2021). In the region where the study was carried out, the Getaria colony largely relies on fish discards/fishery waste taken from the harbour located next to that colony (just some hundreds of meters), while birds in the Ulia colony depend more on landfills and, in summer, also on invertebrates (earthworms) (Arizaga et al. 2013, Zorrozua et al. 2020a). Our results support other studies where chicks BC is highly influenced by diet, with those being fed with marine prey (fish) are in better condition than those fed with other food types (Ramos et al. 2009a).

In this line, it was not surprising that the Getaria colony was the one where the chicks showed higher mean values of BC. The better BC of these chicks would not only allow a longer life expectancy during the pre-fledging period, but also, probably, a better post-fledging survival prospect (Arizaga et al. 2015), especially in a moment of their life cycle when having high fuel reserves could be fundamental to overcome the critical period on becoming independent. All this could also have long-term demographic consequences, in terms of survival or recruitment

Table 2. Top-ranked models used to test the effect of the colony, year as numeric and weather on Yellow-ledged Gull chicks body condition (BC parameter), ranked according to their small sample size-corrected Akaike values (AICc). Moreover, we also show the models with an effect of the colony, year, or both, as well as the null one (with only a tarsus effect). Abbreviations: Δ AICc — difference in AICc in relation to the top-ranked model; df — degrees of freedom. Weather variables: temperature (temp), rainfall (rain); for the months, 'm' is May, 'j' is June. All models included a random colony-year effect.

Models	AICc	AAICo	df
	71100		ŭ
tarsus+colony+temp _m +temp _i +year	35612.19	0.00	9
tarsus+colony+temp _m +temp _i	35613.21	1.02	8
tarsus+colony+temp _m +temp _i +year+rain _i	35613.67	1.48	10
tarsus+colony+temp +temp +rain	35614.43	2.24	9
tarsus+colony+year	35623.98	11.79	7
tarsus+colony	35624.87	12.68	6
tarsus+year	35638.29	26.10	5
tarsus	35639.33	27.14	4

Table 3. Beta-parameter estimates obtained from the topranked model from Table 2, which includes an additive effect of year as numeric, weather $(temp_m + temp_i)$, colony and tarsus length on Yellow-ledged Gull chicks body condition (BC parameter). Reference factors (Beta = 0): Colony: Ulia.

Fixed effects	Beta	SE(Beta)	p-value
Tarsus length	-0.58	0.30	0.058
Colony: Getaria	+18.90	7.82	0.022
Colony: Santa Clara	-1.24	8.02	0.878
Temp _m	+9.62	5.18	0.072
Temp	-14.66	7.65	0.065
Year	+1.00	1.40	0.478

(Arizaga et al. 2015). It should be highlighted here that, to date, the Yellow-legged Gull colonies in Gipuzkoa have very marginal, virtually null natal dispersal rates (Delgado et al. 2021a), in such a way that the chicks born in each of the colonies are the ones that will ensure the long-term persistence of these colonies. In contrast, the poorer BC of the Santa Clara and Ulia chicks, would be compatible with what seems a worse scenario, which could be related to the demographic recession occurring in Ulia (Arizaga et al. 2022). The fact that the largest colony had the lowest BC is also compatible with potential density-dependent mechanisms (Newton 2013).

The BC did not show a linear trend, but seemed to fluctuate from year to year. Weather, moreover, also seemed to have an effect on BC, even though its effect seemed to be more marginal as compared to other predictors which were found to have a much higher impact. This result could be due to the fact that chicks are able to compensate for the effect of days with adverse weather (e.g., due to heavy rains, cold spells, etc.),



Fig. 2. Predicted marginal mean ($\pm 95\%$ confidence interval) Yellow-ledged Gull chicks body condition (BC parameter), in relation to colony, according to the top-ranked model from Table 2.

maybe because their parents can afford for these potential effects. Bad weather in spring is not persistent and several 'bad' days within the region are normally followed by dry and warmer days. However, springs with prevailing adverse weather, especially rain, might have an impact on chicks BC, though we should acknowledge that we were not able to demonstrate such an effect. We observed an opposite effect of temperature on BC across the spring. In May, coinciding with lateincubation and hatching period (Arizaga et al. 2012), higher temperatures improved BC (probably because the weather is colder and the chicks are not yet able to thermoregulate). In June, however, higher temperatures showed a negative effect on BC. This could be given that in June chicks are older and spend longer periods alone, so too hot days may impact negatively on them. Climate change is expected to increase the number of extreme and violent meteorological episodes in regions like Gipuzkoa (Bay of Biscay). Our models predict moderate effects of weather on chicks BC, but we cannot reject that very adverse springs could have a higher significant impact.

In conclusion, we observed that BC of a resident Yellow-legged Gull population from the Bay of Biscay varied substantially in relation to colony. Prevailing meteorological conditions also seemed to, more moderately, explain the pattern of this variation. We suppose that the main environmental driver explaining our results may be food availability, but weather may also have an impact.

ACKNOWLEDGEMENTS

Thanks to all volunteers who collaborated to ring chicks. The Gipuzkoa Regional Administration authorized ringing activity. Research was partly funded by the Gipuzkoa Administration and the Basque Government. An anonymous reviewer provided very valuable comments that helped us to improve an earlier version of this work.

REFERENCES

- Arcos J. M., Arizaga J., Barros Á., Fernández-Pajuelo M., et al. 2022. [Yellow-legged Gull *Larus michahellis*]. In: López-Jiménez N. (Ed). [Red List of Birds of Spain]. SEO/BirdLife, Madrid, pp. 814–816.
- Arizaga J., Aldalur A., Cuadrado J. F., Díez E., Goikoetxea J., Herrero A., Jauregi J. I., Laso M., Sánchez J. M. 2012. [Breeding parameters of the Yellow-legged Gull *Larus michahellis lusitanius* Naumann, 1840 in Gipuzkoa]. Munibe 60: 167–174.

- Arizaga J., Galarza A., Delgado S., Zorrozua N., Aldalur A., Carazo Ó., Zubiaur J. 2022. [Decline of the Yellow-legged Gull *Larus michahellis* breeding population on the Basque coast (eastern Bay of Biscay) during the period 2000–2021]. Munibe 70: 7–19.
- Arizaga J., Herrero A., Aldalur A., Cuadrado J. F., Oro D. 2015. Effect of pre-fledging body condition on juvenile survival in Yellow-legged Gulls *Larus michahellis*. Acta Ornithol. 50: 139–147.
- Arizaga J., Herrero A., Aldalur A., Zorrozua N., Delgado S., Laso M. 2020. [15 years of monitoring of the Yellow-legged Gull in Gipukoa]. Rev. Anilla. 39: 38–55.
- Arizaga J., Jover L., Aldalur A., Cuadrado J. F., Herrero A., Sanpera C. 2013. Trophic ecology of a resident Yellowlegged Gull (*Larus michahellis*) population in the Bay of Biscay. Mar. Environ. Res. 87–88: 19–25.
- Arizaga J., Zorrozua N., Egunez A. 2018. Between the land and sea: how yellow-legged gulls have changed their dependence on marine food in relation to landfill management. In: Mikkola H. (Ed). Seabirds. IntechOpen, London, UK, pp. 67–78.
- Barton K. 2014. MuMIn: Multi-model inference. R package version 1.10.5.
- Bates D., Maechler M., Bolker B., Walker S. 2014. Ime4: Linear mixed-effects models using Eigen and S4. R package version 1.1-7.
- BirdLife International 2021. European Red List of Birds. Publications Office of the European Union, Luxembourg.
- Braasch A., Schauroth C., Becker P. H. 2009. Post-fledging body mass as a determinant of subadult survival in Common Terns Sterna hirundo. J. Ornithol. 150: 401–407.
- Burnham K. P., Anderson D. R. 1998. Model selection and inference. A practical information theoretic approach. Springer-Verlag, New York.
- Cam E., Aubry L. 2011. Early development, recruitment and life history trajectory in long-lived birds. J. Ornithol. 152: 187–201.
- Cama A., Abellana R., Christel I., Ferrer X., Vieites D. R. 2012. Living on predictability: modelling the density distribution of efficient foraging seabirds. Ecography 35: 912–921.
- Camphuysen K. C. J., Shamoun-Baranes J., van Loon E. E., Bouten W. 2015. Sexually distinct foraging strategies in an omnivorous seabird. Mar. Biol. 162: 1417–1428.
- Carmona M., Aymí R., Navarro J. 2021. Importance of predictable anthropogenic food subsidies for an opportunistic gull inhabiting urban ecosystems. Eur. J. Wild. Res. 67: 9.
- Christensen-Dalsgaard S., May R. F., Barrett R. T., Langset M., Sandercock B. K., Lorentsen S. H. 2018a. Prevailing weather conditions and diet composition affect chick growth and survival in the black-legged kittiwake. Mar. Ecol. Prog. Series 604: 237–249.
- Christensen-Dalsgaard S., May R., Lorentsen S.-H. 2018b. Taking a trip to the shelf: Behavioral decisions are mediated by the proximity to foraging habitats in the blacklegged kittiwake. Ecol. Evol. 8: 866–878.
- Delgado S., Herrero A., Aldalur A., Arizaga J. 2021a. High philopatry rates of Yellow-legged Gulls in the southeastern part of the Bay of Biscay. Avian Res. 12: 36.
- Delgado S., Herrero A., Galarza A., Aldalur A., Zorrozua N., Arizaga J. 2021b. Demographic impact of landfill closure on a resident opportunistic gull. Pop. Ecol. 63: 238–246.
- Egunez A., Zorrozua N., Aldalur A., Herrero A., Arizaga J. 2017. Local use of landfills by a yellow-legged gull population suggests distance-dependent resource exploitation. J. Avian Biol. 49: e01455.
- Erikstad K. E., Fauchald P., Tveraa T., Steen H. 1998. On the cost of reproduction in long-lived birds: the influence of environmental variability. Oikos 83: 431–438.

- Fernández A., Aldalur A., Herrero A., Galarza A., Hidalgo J., Arizaga J. 2017. Assessing the impact of colour-ring codes on parameter estimates from Cormack–Jolly–Seber models: a test with the Yellow-legged Gull (*Larus michahellis*). J. Ornithol. 158: 323–326.
- Greńo J. L., Belda E. J., Barba E. 2008. Influence of temperatures during the nestling period on post-fledging survival of Great Tit *Parus major* in a Mediterranean habitat. J. Avian Biol. 39: 41–49.
- Isaksson N., Evans T. J., Shamoun-Baranes J., Åkesson S. 2016. Land or sea? Foraging area choice during breeding by an omnivorous gull. Mov. Ecol. 4: 14.
- Jordi O., Arizaga J. 2016. Sex differences in growth rates of Yellow-legged Gull *Larus michahellis* chicks. Bird Study 63: 273–278.
- Méndez A., Montalvo T., Aymí R., Carmona M., Figuerola J., Navarro J. 2020. Adapting to urban ecosystems: unravelling the foraging ecology of an opportunistic predator living in cities. Urb. Ecosyst. 23: 1117–1126.
- Monticelli D., Ramos J. A. 2012. Laying date, body mass and tick infestation of nestling tropical Roseate Terns *Sterna dougallii* predict fledging success, first-year survival and age at first return to the natal colony. Ibis 154: 825– 837.
- Morais L., Santos C., Vicente L. 1998. Population increase of Yellow-legged Gulls *Larus cachinnans* breeding on Berlenga Island (Portugal), 1974–1994. Sula 12: 27–38.
- Moreno R., Jover L., Munilla I., Velando A., Sanpera C. 2009. A three-isotope approach to disentangling the diet of a generalist consumer: the yellow-legged gull in northwest Spain. Mar. Biol. 157: 545–553.
- Newton I. 2013. Bird populations. Collins New Naturalist Library, London.
- Olsen K. M., Larson H. 2004. Gulls of Europe, Asia and North America. Christopher Helm, London.
- Oro D., Martinez-Abrain A. 2007. Deconstructing myths on large gulls and their impact on threatened sympatric waterbirds. Anim. Cons. 10: 117–126.
- Payo-Payo A., Oro D., Igual J. M., Jover L., Sanpera C., Tavecchia G. 2015. Population control of an overabundant species achieved through consecutive anthropogenic perturbations. Ecol. Appl. 25: 2228–2239.
- R Core Team 2023. R: A language and environment for statistical computing. R Foundation for Statistical Computing, Vienna, Austria.
- Ramírez F, Afán I., Bouten W., Carrasco J. L., González-Forero M., Navarro J. 2020. Humans shape the year-round distribution and habitat use of an opportunistic scavenger. Ecol. Evol. 10: 4716–4725.
- Ramos R., Ramirez F. J., Sanpera C., de Jover L., Ruiz X. 2006. Feeding ecology of Yellow-legged Gulls in four colonies along the western Mediterranean: An isotopic approach. J. Ornithol. 147 (Suppl. 1): 235–236.
- Ramos R., Ramirez F., Sanpera C., Jover L., Ruiz X. 2009a. Diet of Yellow-legged Gull (*Larus michahellis*) chicks along the Spanish Western Mediterranean coast: the relevance of refuse dumps. J. Ornithol. 150: 265–272.
- Ramos R., Ramirez F., Sanpera C., Jover L., Ruiz X. 2009b. Feeding ecology of yellow-legged gulls *Larus michahellis* in the western Mediterranean: a comparative assessment using conventional and isotopic methods. Mar. Ecol. Prog. Series 377: 289–297.
- Raven S. J., Coulson J. C. 1997. The distribution and abundance of *Larus* gulls nesting on buildings in Britain and Ireland. Bird Study 44: 13–34.
- Reiertsen T. K. 2013. Seabirds, climate and prey: A population study of two seabird species. PhD Thesis, University of Tromsř, Norway.

- Rodríguez C., Bustamante J. 2003. The effect of weather on lesser kestrel breeding success: can climate change explain historical population declines? J. Anim. Ecol. 72: 793– 810.
- Stearns S. C. 1992. The evolution of life histories. Oxford University Press, Oxford.
- Vidal E., Medail F., Tatoni T. 1998. Is the yellow-legged gull a superabundant bird species in the Mediterranean? Impact on fauna and flora, conservation measures and research priorities. Biodiver. Conserv. 7: 1013–1026.
- Zorrozua N., Aldalur A., Herrero A., Diaz B., Delgado S., Sanpera C., Jover L., Arizaga J. 2020a. Breeding Yellowlegged Gulls increase consumption of terrestrial prey after landfill closure. Ibis 162: 50–62.
- Zorrozua N., Delgado S., Aldalur A., Arizaga J. 2020b. Adverse weather reduces the spatial use of an opportunistic gull. Behaviour 157: 667–681.
- Zorrozua N., Egunez A., Aldalur A., Galarza A., Díaz B., Hidalgo J., Jover L., Sanpera C., Castège I., Arizaga J. 2020c. Evaluating the effect of distance to different food subsidies on the trophic ecology of an opportunistic seabird species. J. Zool. 311: 45–55.
- Zorrozua N., Granado I., Fernandes-Salvador J. A., Louzao M., Basterretxea M., Arizaga J. 2023. Evaluating the dependence of opportunistic Yellow-legged Gulls (*Larus michahellis*) on marine habitat and fishing discards. Ibis 166: 112–128.

STRESZCZENIE

[Czynniki wpływające na kondycję piskląt w populacji mewy romańskiej]

Zapewnienie pisklętom wystarczającej ilości pokarmu ma kluczowe znaczenie nie tylko dla ich wzrostu, ale także pozwala na gromadzenie zapasów, które ptaki mogą wykorzystać w trakcie potencjalnych niedoborów pożywienia w przyszłości. Stąd lepiej odżywione pisklęta mają większą szansę na przeżycie w sytuacji nagłego załamania pogody. Ponadto, przeżywalność młodych ptaków w okresie po opuszczeniu przez nie gniazda jest związana z ich masą ciała w okresie pisklęcym. Kondycja piskląt jest więc ważna dla określania długoterminowej dynamiki populacji i jednocześnie może być pewnego rodzaju wskaźnikiem jakości danego sezonu lęgowego. Mewa romańska jest najliczniejszą mewą w południowozachodniej Palearktyce, ale gatunek ten wykazuje bardzo szybki spadek liczebności bezpośrednio przypisywany niedoborom pożywienia, w szczególności związanym z zamykaniem wysypisk śmieci. Należy przewidywać, że tak nagłe i drastyczne ograniczenie dostępności pożywienia powinno mieć silny wpływ na pisklęta, ale badania dotyczące tego, jak kondycja piskląt mewy romańskiej zmienia się corocznie, także pod wpływem innych czynników środowiskowych,

w tym pogody, są nadal nieliczne. Celem pracy było określenie wpływu kolonii lęgowej, roku oraz pogody na kondycję piskląt na podstawie wieloletnich danych zebranych podczas obrączkowania piskląt mewy romańskiej w koloniach zlokalizowanych wzdłuż wybrzeża w południowo-wschodniej części Zatoki Biskajskiej (północna Hiszpania), w prowincji Gipuzkoa.

Badania prowadzono w trzech koloniach mewy romańskiej: Getaria, Santa Clara i Ulia liczących odpowiednio 145, 100 i 850 par legowych. Maksymalna odległość między koloniami wynosiła 20 km. Ptaki z kolonii Getaria mają wyższy udział pokarmu pochodzącego z morza (głównie odpady w porcie rybackim) niż w dwóch pozostałych koloniach, w których ptaki latem żerują na wysypiskach, wykorzystują pokarm pochodzenia antropogenicznego i zdobywany na lądzie (np. dżdżownice). Pisklęta były obrączkowane w wieku 20-30 dni, pod koniec czerwca, w latach 2007-2020. Ptaki były ważone i mierzono im skok, łącznie zebrano dane dla ponad 3 tys. piskląt (Tab. 1). W analizach kondycję piskląt określono jako wartości resztowe z regresji logliniowej masy ciała i długości skoku (Fig. 1). Dane pogodowe obejmowały miesięczną sumę opadów oraz średnią miesięczną minimalną dzienną temperaturę osobno dla maja (okres wysiadywania i klucia się piskląt) i czerwca (okres karmienia piskląt) (Apendyks 1).

Najlepszy model wg kryterium informacyjnego Akaike (AIC) zawierał efekt kolonii, roku (zmienna ciągła opisująca trend czasowy) oraz temperatury w maju i czerwcu (Tab. 2). Model uwzględniający dodatkowo opady w czerwcu był równie wiarygodny. Najlepszy model wyjaśniał 20.8% zmienności, przy czym czynnik losowy (efekt kolonii w danym sezonie) — aż 16.6% (Apendyks 2). Ten ostatni wynik wskazuje, że w danej kolonii kondycja piskląt różniła się między latami, tym samym potwierdzając wpływ roku na kondycję piskląt. Pisklęta z kolonii Getaria były w lepszej kondycji niż w pozostałych koloniach (Tab. 3, Fig. 2). Nie stwierdzono występowania trendu wieloletniego w kondycji piskląt (Tab. 3). Generalnie nie stwierdzono także wpływu temperatury na kondycję piskląt, jednak wszystkie wiarygodne modele zawierały te zmienne, a w najlepszym modelu efekt tych parametrów był bliski istotności statystycznej (Tab. 2, 3). Co ważne, temperatury maja i czerwca miały przeciwstawny wpływ na pisklęta: wyższe temperatury w maju wiązały się z lepszą kondycją młodych, zaś w czerwcu wpływały na kondycję negatywnie (Tab. 3).

Autorzy wskazują, że głównym czynnikiem środowiskowym wyjaśniającym uzyskane wyniki jest najprawdopodobniej dostępność pożywienia, choć pogoda w sezonie lęgowym może także mieć wpływ na kondycję piskląt.



Appendix 1. Accumulated precipitation and mean of the minimum daily temperature in spring in the study area. Source: Igeldo meteorological station (AEMET).

Appendix 2. Relationship of the mean observed and predicted body condition of Yellow-ledged Gull chicks for each year and colony, according to the top-ranked model from Table 2.

