Mollusk shells in feeding sites of Yellow-legged Gull (*Larus michahellis*): a note from San Pietro island (South Sardinia)

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Abstract

We provided data from mollusk shells (Cephalopoda, Bivalvia, Gastropoda) sampled in a large sample of feeding sites of a nesting colony of *Larus michahelli*s, located in a circum-Sardinian Island. We recorded 59 items (8 taxa) from 298 sites with a dominance (>74%) of cuttlebones of Sepia cuttlefish and, only secondarily, valves of *Mytilus galloprovincialis* Lamarck, 1819 (10.2%) and other taxa. Living mollusks represent a source of proteins and shells providing a calcium supplement for chick's development. Further comparative and experimental research are needed to investigate the rate of peck marking on polystyrene fragments, probably misperceived for *Sepia* cuttlebones.

Key words: Sepia cuttlebones, proteins, calcium, polystyrene, Sardinia.

Riassunto

Presenza di conchiglie di molluschi in siti di alimentazione di Gabbiano reale mediterraneo (*Larus michahellis*)(Isola di San Pietro, Sud Sardegna)

In questa nota alcuni dati relativi alla presenza di molluschi cefalopodi, bivalvi e gasteropodi (8 taxa) raccolti in siti di alimentazione (n=298) in una colonia nidificante di Gabbiano reale (*Larus michahellis*) su un'isola circum-sarda, sono stati riportati. Gli ossi di seppia (*Sepia* sp.) sono risultati dominanti (>74%) mentre, solo secondariamente, sono stati riscontrate valve di *Mytilus galloprovincialis* Lamarck, 1819 (10.2%) e di altri taxa. I molluschi viventi rappresentano una sorgente di proteine, mentre le conchiglie possono fornire un apporto di calcio per adulti e pulli. Sono riportate evidenze di beccate su frammenti di polistirolo, probabilmente confusi con ossi di seppia: a tale riguardo questa nota vuole stimolare ulteriori ricerche sperimentali su questo aspetto comportamentale che mostra implicazioni conservazionistiche.

Parole chiave: Ossi di seppia, proteine, calcio, polistirolo, Sardegna.

Introduction

Many seabirds feed on marine mollusks, a source of proteins or use their shells for mineral absorption (Barrett *et al.*, 2007). In this short note we reported the results of an intensive post-reproductive survey focused on mollusk shells occurring in feeding sites (hereafter 'sites') of a breeding colony of Yellow-legged gull *Larus michahellis* Naumann, 1840 located in a circum-Sardinian island.

The study area is located in Capo Sandalo (coordinates 39°08'50.1"N, 8°13'14.3"E), a rocky small peninsula (rhyolitic ignimbrite, commendite; Garbarino et al., 1990; Di Gregorio et al., 2007), in the far west of the Island of San Pietro (South Sardinia), an area of high interest for the presence of habitat types and bird species of high conservation concern (LIPU Oasi and Special Area of Conservation code ITB040027; details in Battisti, 2018; Fig. 1). Along the cliff slopes, the vegetation includes *Limonium sardoum, Malva arborea*, *Inula chrytmoides*, *Lotus creticus*, *Echinophora spinosa* and two dominant non-native nitrophilous plant species (*Malephora crocea*, *Mesembrynthemum crystallinum*; box in Fig. 1; details in Battisti & Fanelli, 2021). We carried out the survey in summer 2019 (10, 18, 20 and 25 August; research effort about: 10 hours) beyond the end of the nesting phase, when no gull individual was present on site. The area studied was near to a path routinely traveled by tourists in the summer period, therefore there was no disturbance either to gulls or to the other species locally occurring (e.g., *Falco eleonorae*, *Ichthyaetus audouinii*, *Phalacorocorax aristotelis*, *Corus corax*, *Columba livia*, *Monticola solitarius*). All the mollusks occurring in "feeding sites" (i.e. any space of about 1-5 square meters with the presence of excrements, pellets, and anato-

Fig. 1. An image of Capo Sandalo (San Pietro island, South Sardinia), nesting area of Larus michahellis. In the foreground, two non-native nytrophilous plants (left: Malephora crocea; right: Mesembryanthemum cristallinum). In the box a particular of a feeding site.

mical remains which differs from the surrounding context in terms of vegetation cover and the presence of seagull traces) have been collected and included in sterile bags. For taxonomic diagnosis, we referred to Giannuzzi-Savelli et al. (1994, 1996, 1999, 2003, 2014) and Huber (2010, 2015). Taxonomic nomenclature and systematic were updated using the WoRMS – World Register on Marine Species website (http://www.marinespecies.org).

Results

On 298 feeding sites, we obtained 59 records of mollusk shells (19.79% of sites), belonging to 8 taxa (Tab. 1; Fig. 2B). Cuttlebones of cuttlefish (intact or fragments) were the dominant shells (74.6%), attributable mainly to *Sepia* genus (Linnaeus, 1758), probably *Sepia officinalis* (the bad state of shells does not allow a species-specific attribution). All cuttlebones showed peck marks made by gulls (always on the ventral side, softer; Fig. 2A), as already observed at other Mediterranean sites (Battisti, 2020a).

Taxa	n	fr
Gastropoda		
Trochidae ind. Rafinesque, 1815		
Osilinus sp. Philippi, 1847	1	0.017
Muricidae Rafinesque, 1815		
Bolinus brandaris (Linnaeus, 1758)	1	0.017
Hexaplex trunculus (Linnaeus, 1758)	1	0.017
Bivalvia		
Mytilidae Rafinesque, 1815		
Mytilus galloprovincialis Lamarck, 1819	6	0.102
Cardiidae Lamarck, 1809		
Cerastoderma glaucum (Bruguière, 1789)	2	0.034
Mactridae Lamarck, 1809		
Eastonia rugosa (Helbling, 1779)	2	0.034
Mactra stultorum (Linnaeus, 1758)	1	0.017
Veneridae Rafinesque, 1815		
Chamelea gallina (Linnaeus, 1758)	1	0.017
Cephalopoda		
Sepiidae Keferstein, 1866		
Sepia cfr. *officinalis* Linnaeus, 1758 *	44	0.746
Total	59	1

Tab. 1. List of mollusk taxa (systematic order) sampled in feeding sites of *Larus michahellis* in Capo Sandalo (San Pietro island), with its number and relative frequency. *

Fig. 2. Mollusk shells recorded in feeding sites of Mediterranean Gulls. A: A selection of cuttlebones of *Sepia* cuttlefish (peck marks are visible always in the ventral side). B: A sub-sample of mollusk shells (1: *Mytilus galloprovincialis*, 2: *Hexaplex trunculus*, 3: *Chamalaea galina*; 4: *Eastonia rugosa*; 5: *Cerastoderma glaucum*).

Previous studies evidenced as floating objects, as the cuttlebones of *Sepia* cuttlefish (i.e. the internal partly air—filled cephalopod shells used in regulating the animal's buoyancy; Denton & Gilpin-Brown, 1961), attract seabirds, mainly gulls (Cadée, 2002; Vandendriessche et al., 2007). Other shells, belonging to mollusks living in benthic environments are not directly preyed upon; if anything, their shells are collected when the animals are beached or, analogously to *Sepia* cuttlebones, floating on the water surface.

External mollusk shells and internal *Sepia* cuttlebones serve as a calcium supplement to developing chicks (Cotton, 1960; Goutner, 1994; Gonzàlez-Solís et al., 1997; Battisti, 2020a). Indeed, birds need calcium carbonate for their skeleton, increasing amount during the egg formation period (Cadée, 2002). However, excluding *Sepia* cuttlebones, other mollusks can be ingested (the living organisms representing a source of proteins), and their shells may survive to digestion being excreted through pellets (Barrett et al., 2007).

However, in addition to shells we also detected food remains of predation (*Oryctolagus cuniculus* bones, *Rattus* sp. skull and jaws, chicken bones, butcher waste, olive seeds, gull's egg fragments, shells of goose barnacles - Crustacea Cirripedia). In this regard, we observed specimens of *Podarcis tiliguerta* and terrestrial mollusks as scavenger feeding on food remains, suggesting a detritus chain. We also observed a large amount (n = 106 items) of anthropogenic litter (cellophane for food packaging, polystyrene, bottle/containers caps in high-density polyethylene – HDPE, fishing float), rope fragments, indeterminate tissue fragments, aluminum foil, piece of paper; details in Battisti, 2020b). Polystyrene fragments (n=6), showed gull's peck marks: this fact may suggest as these asthese seabirds can confuse these polymers with cuttlefish bones (see Gregory, 2009). The pecking on plastic litter by seabirds has been highlighted as an emergent problem with conservation implication (Ryan, 1987; Cadée, 2002; Seif et al., 2017; Nicastro et al., 2018; review in Battisti et al., 2019; Battisti, 2020b). In this regard, further studies should be carried out using experimental approaches (e.g., comparisons of peck marking activity on *Sepia* cuttlebones vs. polystyrene fragments).

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References

Barrett R.T., Camphuysen K., Anker-Nilssen T., Chardine J.W., Furness R.W., Garthe S., Hüppop O., Leopold M.F., Montevecchi W.A. & Veit R.R., 2007 - Diet studies of seabirds: a review and recommendations. ICES *Journal of Marine Science*, 64: 1675–1691.

Battisti C., 2018 - Synanthropic-dominated biomass in an insular landbird assemblage. *Community Ecology*, 19: 203-210.

Battisti C., 2020a - *Sepia* cuttlebones pecked by birds along a Mediterranean beach: patterns, frequency and a possible conservation implication. *Avocetta*, 44: 95-99.

Battisti C., 2020b - Heterogeneous composition of anthropogenic litter in nests of Yellow-legged gull (*Larus michahellis*) from a small Mediterranean island. *Marine Pollution Bulletin*, 150: 110682

Battisti C., & Fanelli G., 2021 - Alien-dominated plant communities' syntopic with seabird's nests: evidence and possible implication from a Mediterranean insular ecosystem. *Ethology Ecology & Evolution*, DOI: 10.1080/03949370.2020.1870568

Battisti C., Staffieri E., Poeta G., Sorace A., Luiselli L. & Amori G., 2019 - Interactions between anthropogenic litter and birds: A global review with a 'black-list' of species. *Marine Pollution Bulletin*, 138: 93–114.

Cadée G.C., 2002 - Seabirds and floating plastic debris. *Marine Pollution Bulletin*, 44: 1294–1295.

Cotton B.C. 1960. Mollusca eaten by birds. *South Australian Ornithologist*, 23: 44–47.

Denton E.J. & Gilpin-Brown J.B., 1961 - The buoyancy of the cuttlefish, Sepia officinalis (L.). J*ournal of the Marine Biological Association of the United Kingdom*, 41(2): 319-342.

Di Gregorio F., Panizza V., Piras G. & Ricciu D., 2007 - Carta dei geositi e dei geomorfositi dell'isola di San Pietro (Sardegna SW), *3° Congr. Naz. Geol. e Turismo*. Bologna 1-2-3 marzo 2007, Ed. S.El.Ca. Firenze.

Garbarino C., Lirer L., Maccioni L. & Salvadori I., 1990 - *Carta vulcanologica dell'Isola di San Pietro* (Sardegna). 1:25,000. SELCA, Firenze.

Giannuzzi-Savelli R., Pusateri F., Palmeri A. & Ebreo C., 1994 - *Atlante delle conchiglie marine del Mediterraneo. Vol I: Archaeogastropoda*. Conchiglia, Rome.

Giannuzzi-Savelli R., Pusateri F., Palmeri A. & Ebreo C., 1996 - *Atlante delle conchiglie marine del Mediterraneo. Vol II: Caenogastropoda parte I: Discopoda – Heteropoda*. Conchiglia, Rome.

Giannuzzi-Savelli R., Pusateri F., Palmeri A. & Ebreo C., 1999 - *Atlante delle conchiglie marine del Mediterraneo. Vol III: Caenogastropoda parte II: Ptenoglossa*. Conchiglia, Rome.

Giannuzzi-Savelli R., Pusateri F., Palmeri A. & Ebreo C., 2003 - *Atlante delle conchiglie marine del Mediterraneo. Vol IV: Neogastropoda: Muricoidea*. Conchiglia, Rome.

Giannuzzi-Savelli R., Pusateri F., Micali P., Nofroni I. & Bartolini S., 2014 - *Atlante delle conchiglie marine del Mediterraneo. Vol V: Heterobranchia*. Edizioni Danaus, Palermo.

Gonzàlez-Solís J., Oro D., Pedrocchi V., Jover L. & Ruiz X. 1997 - Bias associated with diet samples in Audouin's gulls. T*he Condor*, 99: 773-779.

Goutner V. 1994 - The diet of Mediterranean Gull (Larus melanocephalus) chicks at fledging. *Journal für Ornithologie*, 135: 193-201.

Gregory, M. R. 2009. Environmental implications of plastic debris in marine settings. *Phil. Trans. R. Soc*. B 364: 2013-2025.

Huber M., 2010 - *Compendium of Bivalves. A Full-Color Guide to 3,300 of the World's Marine Bivalves. A Status on Bivalvia after 250 Years of Research*. Hackenheim, ConchBooks: 901.

Huber M., 2015 - *Compendium of Bivalves 2*. Hackenheim, ConchBooks: 907.

Nicastro K.R., Savio R.L., McQuaid C.D., Madeira P., Valbusa U., Azevedo F., Casero M., Lourenco C. & Zardi G.I., 2018 - Plastic ingestion in aquatic-associated bird species in southern Portugal. *Marine Pollution Bulletin*, 126: 413–418.

Ryan P.G., 1987 - The incidence and characteristics of plastic particles ingested by seabirds. *Marine Environmental Research*, 23: 175–206.

Seif S., Provencher J.F., Avery-Gomm S., Daoust P.Y., Mallory M.L. & Smith P.A., 2017 - Plastic and non-plastic debris ingestion in three gull species feeding in an urban landfill environment. *Arch. Environ. Contam. Toxicol.*, 74: 349-360.

Vandendriessche S., Stienen E.W., Vincx M. & Degraer S., 2007 - Seabirds foraging at floating seaweeds in the Northeast Atlantic. *Ardea*, 95: 289-299.