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**NO EVIDENCE FOR TRADE-OFF BETWEEN EGG  
DIMENSIONS AND CLUTCH SIZE IN FIRST, SECOND  
AND THIRD CLUTCHES OF THE TREE  
SPARROW *Passer montanus***

*Izostanak podrške hipotezi ustupka između dimenzija i broja jaja tijekom  
prvog, drugog i trećeg gniježđenja poljskog vrapca *Passer montanus**

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**ABSTRACT**

The trade-off between egg dimensions and clutch size is an important factor in life-history theory. Compromise between egg size and clutch size has been demonstrated in many species with negative, positive and non-significant correlations. The aim of the present study was to examine the relationship between egg dimensions (length, breadth, volume) and clutch size in a Croatian population of the Tree Sparrow *Passer montanus* for their first, second and third clutches in 2019. Neither negative nor positive associations were found between clutch size and egg dimensions in this study. Results do not support predictions based on the hypothesis of compromise between egg size (egg dimensions) and the number of eggs laid per nest (optimal clutch size/egg size).

**Keywords:** trade-off hypothesis, egg dimensions, clutch size, Tree Sparrow, *Passer montanus*

## INTRODUCTION

Trade-off between egg dimensions and clutch size is an important factor of life-history theory (LACK 1947, SMITH & FRETWELL 1974, BROCKELMAN 1975). Combination of egg size and clutch size determines the total investment by females during the reproductive period. According to HŔRAK *et al.* (1995), “being hatched from a large egg could potentially be beneficial of the laying female, however, high investment into egg quality (size) might conflict with her own energetic demands and willingness to produce more offspring”. Studies have found negative (MARTIN *et al.* 2006, BAŇBURA *et al.* 2018), positive (ASLAN & YAVUZ 2010, DOLENEC 2016) and no significant correlations (DOLENEC 2011, BAO *et al.* 2020) between egg size and clutch size. Negative relationships between egg volume (or egg mass) and clutch size is consequence of compromise between egg size and clutch size with females laying numerous small or few large eggs (e.g. BALCH 2017). Positive relationships is likely a consequence of good female quality or/and good environmental conditions (ENCABO *et al.* 2001). A trade-off between egg size and clutch size has been demonstrated in other animal species (e.g. YU & DENG 2020 for amphibians and JORGEWICH-COHEN *et al.* 2022 for reptiles). The trade-off between clutch size and egg size is one of the most challenging questions in reproductive biology. Generally, birds offer a rich subject of the study, given their ecological characteristics.

The aim of the present study was to determine relationship between egg dimensions (length, breadth, volume) and clutch size (the number of eggs in the clutch) of the Tree Sparrow *Passer montanus* in their first, second and third clutches in 2019.

## MATERIAL AND METHODS

The study area was located in an extensive mixed farming area near Mokrice (46° 00' N, 15° 55' E, ca. 140 m a.s.l.) in northwestern Croatia. Observations were made at a nestbox colony during the breeding season of 2019 (March – July). Nestboxes measured 120 x 120 x 220 mm for internal dimensions with a 32 mm in diameter entrance hole. All nestboxes had a sliding top for minimizing disturbances while nesting was being monitored. Altogether 60 nestboxes had been installed in the autumn of 2018. Average clutch size was calculated as the average number of eggs of all complete first, second and third clutches laid. Egg maximum length (L) and breadth (B) were measured using sliding callipers to the nearest 0.01 mm. Egg volume (V) was calculated as  $V = 0.51 \times L \times B^2$  (HOYT 1979) and the mean egg size of each nest in analyses was calculated. Since egg mass fluctuates during incubation (GRANT *et al.* 1982), I did not use this variable. Statistical analysis between egg dimensions and clutch size was performed by Pearson's correlation using the SPSS 17.0 statistical package. Significance was tested with Student's t-test. P-values < 0.05 were considered statistically significant.

## RESULTS AND DISCUSSION

During 2019, first clutch occupancy was 86.7% (52 nestboxes), second clutch occupancy 78.3% (47 nestboxes) and third clutch occupancy 58.3% (35 nestboxes).

First clutches. – Average egg length and egg breadth of Tree Sparrow eggs in first clutches were  $18.64 \pm 0.98$  mm (range 16.39–20.54 mm) and  $13.99 \pm 0.51$  mm (range 13.09– 15.32 mm), respectively. Average egg volume was  $1.86 \pm 0.21$  cm<sup>3</sup> (range 1.45–2.44 cm<sup>3</sup>). Average clutch size was  $5.09 \pm 0.49$  (range 4–6), modal clutch size was 5 eggs. Correlation between egg length and breadth was significant [(Pearson's coefficient ( $r$ ) = 0.49,  $p < 0.001$ ,  $n = 52$ )]. Correlation between clutch size and egg dimensions were not significant: egg length ( $r = 0.22$ ,  $p = 0.111$ ,  $n = 52$ ), breadth ( $r = 0.17$ ,  $p = 0.23$ ,  $n = 52$ ) and volume ( $r = 0.23$ ,  $p = 0.107$ ,  $n = 52$ ).

Second clutches. – Average egg length and egg breadth in second clutches were  $19.08 \pm 1.01$  mm (range 17.08–21.33 mm) and  $14.12 \pm 0.43$  mm (range 13.25–14.81 mm), respectively. Average egg volume was  $1.94 \pm 0.17$  cm<sup>3</sup> (range 1.57 – 2.28 cm<sup>3</sup>). Average clutch size was  $5.43 \pm 0.74$  (range 4–7), modal clutch size was 5 eggs. Correlation between egg length and breadth was significant ( $r = 0.29$ ,  $p = 0.049$ ,  $n = 47$ ). Correlations between clutch size and egg dimensions were not significant: egg length ( $r = -0.06$ ,  $p = 0.693$ ,  $n = 47$ ), breadth ( $r = 0.22$ ,  $p = 0.139$ ,  $n = 47$ ) and volume ( $r = -0.185$ ,  $p = 0.214$ ,  $n = 47$ ).

Third clutches. – Average egg length and egg breadth in third clutches were  $18.75 \pm 0.86$  mm (range 16.79–21.27 mm) and  $14.09 \pm 0.48$  mm (range 16.79–21.27 mm), respectively. Average egg volume was  $1.91 \pm 0.16$  cm<sup>3</sup> (range 1.55–1.91 cm<sup>3</sup>). Average clutch size was  $4.81 \pm 0.93$  (range 2–7), modal clutch size was 5 eggs. Correlation between egg length and breadth was significant ( $r = 0.44$ ,  $p = 0.009$ ,  $n = 35$ ). Correlations between clutch size and egg dimensions were not significant: egg length ( $r = -0.21$ ,  $p = 0.222$ ,  $n = 35$ ), breadth ( $r = -0.03$ ,  $p = 0.864$ ,  $n = 35$ ) and volume ( $r = -0.14$ ,  $p = 0.428$ ,  $n = 35$ ).

No significant correlation between clutch size and egg dimensions was found suggesting that there is no population-level trade-off between clutch size (fecundity) and egg size (volume) and other egg dimensions in Tree Sparrows. My results are similar with other studies on both passerine (e.g. MITRUS & ROGALA 2001, DOLENEC *et al.* 2005, JOHNSON *et al.* 2006, DOLENEC 2006) and non-passerine species (e.g. HÖRÁK *et al.* 2008, POLAK 2010). In the Eastern Bluebird *Sialia sialis* egg volume was significantly inversely related to clutch size (BALCH 2017). Interestingly, GÓRSKI *et al.* (2015) illustrated that impact of clutch size on egg volume differs between years. In one year, egg volume increased with increasing clutch size, but in other years such correlations were non-significant. In the Tree Swallow *Tachycineta bicolor* this trade-off was most evident among the lightest individuals in the population (PELLERIN *et al.* 2016). According to these authors, a negative trade-off is a consequence of poor female conditions and/or poor en-

vironmental conditions. In the Common Starling *Sturnus vulgaris* of northern Finland egg size increases with increasing clutch size (OJANEN *et al.* 1978), but in northwestern Croatia starling egg sizes are not affected by clutch size (DOLENEĆ *et al.* 2008). SONG *et al.* (2020) found that “plovers allocate resources between egg size and clutch size following the diversified and conservative bet-hedging”.

In this study, no significant correlation between clutch size and egg dimensions (length, breadth and volume) and clutch size were found among first, second and third clutches in Tree Sparrows. Therefore, I conclude that the results of this work do not support predictions based on the hypothesis of compromise between egg size and clutch size.

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## SAŽETAK

Istraživan je odnos između dimenzija jaja (duljine, širine i volumena) i broja jaja u gnijezdu poljskog vrapca *Passer montanus* tijekom prvog, drugog i trećeg legla na području sjeverozapadne Hrvatske 2019. godine, kako bi se utvrdilo eventualno postojanje kompromisa između dimenzija i broja jaja u pologu. Tijekom uzorkovanja korištene su škrinjice za gniježđenje s pokretnim otvorom radi jednostavnog pristupa gnijezdu. Kompromis između veličine jaja i broja snesenih jaja dokazan je kod nekih vrsta ptica ali i nekih drugih životinjskih vrsta. Objavljeni radovi dijelom govore o negativnoj korelaciji, dijelom o pozitivnoj, ali rezultati kod većine istraživanja prezentiraju nepovezanost. Rezultati ovog istraživanja ne podupiru hipotezu ustupka (trade-off), odnosno nije zabilježen kompromis između dimenzija jaja i broja jaja snesenih u pojedino gnijezdo niti u jednom od tri gniježđenja tijekom sezone.