**SUPPLEMENTARY DATA**

**SUPPLEMENTARY TABLE 1.** Cardiac Output in chickens

|  |  |  |  |
| --- | --- | --- | --- |
| Type/age | Cardiac Output mL min-1 kg-1 | Cardiac Output ml min-1 | Reference |
| **Broiler chickens**A  |  |  |
|  | 174 | 492 | Wideman et al., 1996 |
| 4 weeks old | 208 | 253 | Wideman,1999 |
| 5 weeks old | 193 | 348 | Wideman, 1999 |
| 6 weeks old | 188 | 434 | Wideman, 1999 |
|  | 198 | 471 | Wideman et al., 2000 |
|  |  |  |  |
| **Laying hens** |  |  |
|  | 218 | 499 | Sapirstein and Hartman, 1959 |
|  | 227 | 363 | Boelkins et al., 1973. |
|  | 137 | 277 | Moynihan and Edwards, 1975 |
|  | 160B | 257 | Niezgoda et al., 1982 |
|  | 113 | 208 | Niezgoda et al., 1979 |
|  | 179 | 287 | Hrabia et al., 2005 |
|  | 201 | 321 | Rząsa et al., 2008 |
|  |  |  |  |
| **Adult male chicken** |  |  |  |
|  | 186 | 411 | Vogel and Sturkie, 1963 |
|  | 150 | 349 | Merrill et al., 1981 |
|  |  |  |  |
| **Ducks**  |  |  |  |
| Domestic duck (*Anas platyrhynchos*) |  |  |
|  | 529 | 1509 | Folkow et al., 1967 |
|  | 304 | 897 | Grubb, 1982 |
|  |  |  |  |
| Tufted duck (*Aythya fuligula*) |  |  |
|  | 342 | 208 | Bevan and Butler, 1992 |

A Anesthetized

B Assumes body weight of laying chicken is 1.6 kg

**SUPPLEMENTARY TABLE 2.** Studies reporting hematocrit and blood hemoglobin concentrations in sexually immature and mature female chickens together with adult male chickens

|  |  |  |  |
| --- | --- | --- | --- |
|  | Pullet [males] | Laying hens | Reference |
| **Hematocrit** |  |  |  |
|  | 31.1 | 29.6 | Medway and Kare, 1959 |
|  |  | 28.6 | Koji, 1960 |
|  |  | 31.5 | Abou-Ashour and Edwards, 1972 |
|  | 29 [45] | 29 | Sturkie, 1986 citing Newell and Schaffner |
|  | [40.8] | 25.5 | Hunsaker, 1969 |
|  | 25.0 | 23.7 | Schaal et al., 2016 |
|  |  | 29.0 | Pantaya and Utami, 2018 |
|  |  | 25.6 | López et al., 2018 |
|  |  | 23.3 | Sauer et al., 2019 |
|  | 27.6 [33.9] | 26.3 | Arnaudov et al., 2020 |
| Mean + (n = studies) SEM | 28.1 + (4) 1.78[39.9 + (3) 3.24] | 27.1 + (10) 0.86 |  |
| **Hemoglobin** |  |  |  |
|  |  | 9.28 | Abou-Ashour and Edwards, 1972 |
|  | 8.5 | 8.1 | Schaal et al., 2016 |
|  |  | 11.4 | López et al., 2018 |
|  |  | 7.96 | Sauer et al., 2019 |
|  | 9.27 [10.76] | 9.16 | Arnaudov et al., 2020 |
| Mean + (n = studies) SEM | 8.88 + (2) 0.38 | 9.18 + (5) 0.62  |  |

**SUPPLEMENTARY TABLE 3.** Studies reporting hematocrit and blood hemoglobin concentrations in young (4-6 weeks old) broiler chickens

|  |  |  |
| --- | --- | --- |
| **Broiler chickens (male and female)** | Parameter | Reference |
| **Hematocrit %** |  |  |
|  | 29.1 | Kubena et al., 1972 |
|  | 36.2 | Goodwin et al., 1992 |
|  | 28.24 | Yersin et al., 1992 |
|  | 30 | Furlan et al., 1993 |
|  | 34.1 | Altan et al., 2000 |
|  | 30.73 | Orawan and Aengwanich, 2007 |
|  | 34.0 | Tehrani et al., 2012 |
|  | 29.9 | Onyishi et al., 2017 |
|  | 30.2 | de Carvalho et al., 2020 |
| **Mean + (n=studies) SEM**  | **31.4 + (9) 0.90** |  |
| **Hemoglobin** |  |  |
|  | 9.03  | Kubena et al., 1972 |
|  | 9.08 | Yersin et al., 1992 |
|  | 11.6 | Furlan et al., 1993 |
|  | 8.22 | Orawan and Aengwanich, 2007 |
|  | 10.6 | Tehrani et al., 2012 |
|  | 7.43 | de Carvalho et al., 2020 |
| **Mean + (n=studies) SEM** | **9.33 + (6) 0.63** |  |

**SUPPLEMENTARY TABLE 4.** Studies reporting hematocrit and blood hemoglobin concentrations in mallard and domesticated duck

|  |  |  |  |
| --- | --- | --- | --- |
|  | Hct | Hemoglobin | Reference |
| Mallard |  |  |  |
|  | 45.7 | 13.9 | Shave and Howard, 1971 |
|  | 40.2 | 15.2 | Driver, 1982 |
|  | 47.5 | 17.1 | Keijer and Butler, 1982 |
|  | 48.3 |  | Cited Zapletal et al., 2017 |
| Mean + (N = studies) SEM | 45.4 + (4) 1.82 | 15.4 + (3) 0.93 |  |
|  |  |  |  |
| Domestic duck |  |  |  |
|  | 39.8 | 14.2 | Mean of Hemm and Carlton, 1967 |
|  | 44.2 |  | Sturkie, 1986 |
|  | 46.7 |  | Sturkie, 1986 |
|  | 40.7 |  | Sturkie, 1986 |
|  | 38.1 |  | Sturkie, 1986 |
|  | 46 |  | Sturkie, 1986 |
|  | 35.5 |  | Zapletal et al., 2017 |
|  | 40.7 | 13.3 | Bhattacherjee et al., 2018 |
|  | 37.2 | 12.7 | Bhattacherjee et al., 2018 |
|  |  | 14.2 | Sturkie, 1986 |
|  |  | 12.7 | Sturkie, 1986 |
|  |  | 12.7 | Sturkie, 1986 |
| Mean + (N = studies) SEM | 41.0 + (9) 1.30 | 13.3 + (6) 0.30 |  |

**SUPPLEMENTARY TABLE 5**. Studies reporting plasma/serum concentrations of albumen and immunoglobulins in chickens

|  |  |  |
| --- | --- | --- |
|  | Concentration | Reference |
| **ALBUMEN g dL-1** |  |  |
| Young chickens/pullets | 1.72 | Morgan, 1975 |
| Young female chicken | 1.70 | Peltonen and Sankari, 2011 |
| Broilers (< 7 weeks old)  | 1.42 | Bowles et al., 1989 |
| Broilers (< 7 weeks old) | 1.95 | Meluzzi et al., 1992 |
| Broilers (< 7 weeks old) | 1.56 | Liu et al., 2020 |
|  |  |  |
| Laying hens | 1.10 | Patterson et al., 1962 |
| Laying hens | 1.46 | Morgan, 1975 |
| Laying hens | 1.74 | Peltonen and Sankari, 2011 |
| Laying hens | 0.781 | Yuan et al., 2016 |
| Laying hens | 0.880 | Chen et al., 2017 |
|  |  |  |
| **IgY g dL-1** |  |  |
| **Young chickens/pullets** | 0.0948 | Murai et al., 2020 |
|  |  |  |
| **Studies employed in analysis** |
| Laying hens | 0.45 | Patterson et al., 1962 |
| Laying hens | 0.464 | Hamal et al., 2006 |
| Laying hens | 0.704 | Strong, 2014 |
| Laying hens | 0.555 | Agrawal et al., 2016 |
| Laying hens | 0.555 | Chen et al., 2017 |
| Laying hens | 0.4052 | Risk et al., 2018 |
| **Studies not employed in analysis due extremely high and low values** |
| Laying hens | 0.191 | Carlander et al., 2001 |
| Laying hens | 0.0797 | Çetin et al., 2010 |
| Laying hens | 2.104 | Geng et al., 2018 |
|  |  |  |
| **IgA g dL-1** |  |  |
| Young chickens/pullets | 0.0342 | Murai et al., 2020 |
|  |  |  |
| Laying hens | 0.0323 | Hamal et al., 2006 |
| Laying hens | 0.0237 | Chen et al., 2017 |
|  |  |  |
| **IgM g dL-1** |  |  |
| Laying hens | 0.0917 | Hamal et al., 2006 |
| Laying hens | 0.172 | Çetin et al., 2010 |
| Laying hens | 0.0374 | Chen et al., 2017 |
| Laying hens | 0.0253 | Geng et al., 2018 |

**SUPPLEMENTARY TABLE 6.** Reproductive and related organ weights in reproductively mature and immature female chickens

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| Fat pad | Ovary | Oviduct | Liver | Reference |
| **Pullet (immature female chickens)** |
|  | 0.03 |  |  | Maurice et al., 1982 |
| 0.7 | 0.03 |  |  | Sun et al., 2006 |
|  | 0.09 | 0.07 |  | Martinez et al., 2015 |
|  | 0.033 | 0.022 |  | Dunn et al., 2017 |
|  |  |  | 2.0 | Frikha et al., 2009 |
|  |  |  | 2.8 | Saldaña et al., 2015 |
|  |  |  | 2.9 | Guzmán et al., 2015 |
|  |  |  | 1.79 | Martinez et al., 2013 |
|  |  |  | 1.5 | Martinez et al., 2015 |
|  |  |  | 1.5 | Dou et al., 2017 |
|  |  |  | 0.9 | Dou et al., 2017 |
|  |  |  | 1.6 | Lorenz et al., 1938 |
|  |  |  | 1.69 | An et al., 1997 |
|  |  |  | 2.73 | Trampel et al., 2005 |
|  |  |  | 2.96 | Musundire et al., 2018 |
|  |  |  | 2.09 | Neill et al., 1977 |
|  |  |  |  |  |
| **Laying hen (reproductively mature female chickens)** |
|  |  |  | 3.17 | Boelkins et al., 1973 |
|  | 1.25 |  | 2.0 | Brody et al., 1984 |
|  | 2.04 | 2.94 | 1.94 | Chen et al., 2007 |
|  |  |  | 3.26 | El-Din et al., 2018 |
|  | 3.8 |  | 3.15 | Emiola et al., 2011 |
|  |  |  | 1.80 | Esonu et al., 2006 |
|  |  |  | 2.03 | Gao et al., 2014 |
|  |  |  | 2.83 | Gregory and Robins, 1998 |
|  | 2.87 | 2.88 | 2.68 | Hassan et al., 2016 |
|  |  |  | 1.91 | Hopkins and Biely, 1935 |
|  | 2.26 | 1.82 | 1.91 | Joseph et al., 2000 |
|  |  |  | 2.32 | Khan et al., 2010 |
|  | 3.95 | 3.84 |  | Kwakkel et al., 1995 |
|  |  |  | 2.56 | Lorenz et al., 1938 |
|  | 1.95 |  | 2.35 | Machebe et al., 2013 |
|  |  |  | 1.96 | Musundire et al., 2018 |
|  | 2.19 | 2.84 | 2.10 | Nassar et al., 2017 |
|  | 2.32 | 3.10 | 1.99 | Nassar et al., 2017 |
|  |  |  | 2.88 | Neill et al., 1977 |
|  | 2.95A | 2.49A |  | Niezgoda et al., 1982 |
|  |  |  | 1.61 | Ogungbesan et al., 2014 |
| 1.83 | 1.82 | 2.12 | 1.62 | Pishnamazi et al., 2014 |
|  | 2.44 |  |  | Saki et al., 2014a |
|  |  |  | 2.65 | Salmi et al., 2006 |
| 4.4 | 1.53 |  |  | Sun et al., 2006 |
|  | 2.12 |  |  | Sun et al., 2015 |
|  |  |  | 2.33 | Wolford and Polin, 1972 |
| 5.09 | 2.83 | 3.21 | 2.48 | Youssef et al., 2016 |

A Assumes body weight of laying chicken is 1.6 kg

**SUPPLEMENTARY TABLE 7.** Organ weights in reproductively mature and immature female chickens

|  |  |
| --- | --- |
| Organ weights as % of b.wt. | Reference |
| Heart | Gizzard | Kidney | Spleen | Small intestine |
| **Pullet (sexually immature female chickens)** |
|  | 3.46 |  |  |  | Frikha et al., 2009 |
|  | 1.68 |  | 0.125 |  | Maurice et al., 1982 |
|  | 1.2 |  | 0.12 |  | Kokoszyński et al., 2017 |
|  | 3.94 |  |  |  | Saldaña et al., 2015 |
|  | 4.3 |  |  |  | Guzmán et al., 2015 |
|  | 5.24 |  | 0.26 |  | Guzmán et al., 2015 |
|  | 3.33P | 0.65 | 0.19 | 5.79 | Martinez et al., 2013 |
|  | 1.4 | 0.6 | 0.25 | 2.6 | Martinez et al., 2015 |
|  | 1.4 | 0.6 | 0.25 | 1.795 | Dou et al., 2017 |
|  | 0.83 | 0.26 | 0.12 |  | Dou et al., 2017 |
|  | 6.86 | 1.15 | 0.095 |  | Musundire et al., 2018 |
| **Laying hen** |
|  |  | 1.002 | 0.13 |  | Boelkins et al., 1973 |
| 0.43 |  | 0.1 |  |  | Machebe et al., 2013 |
| 0.75 |  | 1.49 | 0.68 |  | El-Din et al., 2018 |
| 0.40 | 0.31 |  |  |  | Esonu et al., 2006 |
| 0.38 | 0.31 | 0.58 | 0.11 |  | Gao et al., 2014 |
| 0.40 | 1.59 |  |  | 3.0 | Salmi et al., 2006 |
| 0.42 | 3.43 | 0.58 | 0.08 | 5.85 | Khan et al., 2010 |
| 0.37 | 2.63 | 0.06 |  | 3.59 | Ogungbesan et al., 2014 |
|  |  | 0.645 | 0.119 |  | Hopkins and Biely, 1935 |
| 0.38 |  | 0.58 | 0.11 |  | Gao et al 2014 |
| 0.48 | 6.27 | 1.24 | 0.17 |  | Emiola et al., 2011 |
|  | 7.91 | 0.75 | 0.094 |  | Musundire et al., 2018 |

P Assumed as other data in the report were out by a factor of 10

**SUPPLEMENTARY TABLE 7A**. Gastro-intestinal organ weights in broiler chickens (>13 days old)

|  |  |  |  |
| --- | --- | --- | --- |
| Proventriculus% g 100g-1 | Gizzard% g 100g-1 | Small intestine % g 100g-1 | ReferenceA |
|  | 4.2 | 4.35 | Iji et al., 2001 |
| 1.12 | 4.98 |  | Zavarize et al., 2012 |
|  |  | 3.98 | Moghaddam and Alizadeh-Ghamsari, 2013 |
|  |  | 2.97 | Wu et al., 2013 |
| 0.36 | 1.3 | 3.57 | Aguila et al., 2014 |
| 0.48 | 1.765 | - | Alshamy et al., 2018 |
| 0.63 | 3.71 | 4.04 | Li et al., 2018 |
| 0.42 | 1.64 | 1.73 | Lan et al., 2020 |
|  |  | 4.49 | Pirgozliev et al., 2020 |
| 0.602 + (5) 0.14 | 2.932 + (6) 0.64 | 3.59 + (7) 0.36 | Mean + (n = ) SEM |

A Reports in which proventriculus, gizzard and small intestine weights or relative weights were either found by the following search parameters: proventriculus or gizzard or small intestine AND broiler chicken AND scholarly or employed the studies listed in supplementary table 9. Data from studies where the birds were <13 days old were omitted as relative weights declined in the first 2 weeks of post-hatching life. Relative weights were either as reported or calculated from the weights and body weights.

**SUPPLEMENTARY TABLE 8.** Comparison of lengths of components (in cm) of the gastro-intestinal tract in chickens

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| Parameter | Duodenum | Jejunum | Ileum | Caeca | Colon/rectum | References |
| 21 d broiler chickens | 11.27 | 25.04 | 28.07 |  |  | Wu et al.,2013 |
| 23 d broiler chickens1 | 22.8 | 41.0 | 38.9 |  |  | de Verdal et al., 2010 |
| 28 d broiler chickens | 34.1 | 123 | 31 |  |  | Nasrin et al., 2012 |
| 5 wk broiler chickens | 32.0 | 70.6 | 66.5 | 33.9 | 10.1 | Alshamy et al., 2018  |
| 5 wk broiler chickens |  |  |  | 40.5 | 11.3 | Kokoszyński et al., 2017 |
| 6 wk broiler chicken | 28.1 | 85.8 | 20.7 | 13.8 | 6.7 | Metzler-Zebeli et al., 2018 |
| 9 wk chickens2 | 30.2 | 58.7 | 51.5 | 29.7 | 9.9 | Alshamy et al., 2018 |
| 12 wk white Leghorn male chickens | 22.0 | 47.8 | 43.7 |  |  | Mitjans et al., 1997 |
| Laying hen | 24.3 | 48.8 | 34.5 |  |  | Hurwitz et al., 1973 |
| Laying hen | 27.6 | 56.7 | 54.7 |  |  | Yang et al., 2013 |
| Laying hen | 33.3 | 46.8 | 57.7 | 26.7 | 9.6 | Cutrignelli et al., 2018 |
| Laying hen | 25.12 | 53.92 | 54.24 |  |  | Ding et al., 2018 |
| **Mean + (n = ) SEM**  | 26.6 + (10) 2.1  | 59.3 + (9) 6.03 | 42.7 + (10) 4.6 | 28.1 + (5) 3.9 | 9.48 + (5) 0.72 |  |

**SUPPLEMENTARY TABLE 9.** Small intestine morphometric parameters in chickens

|  |  |  |  |
| --- | --- | --- | --- |
| Parameter | Data | Species and age | Reference |
| **Villus Height μm** |  |  |  |
| **Duodenum** |  |  |  |
|  | 674 | Broiler chickens | Xu et al., 2003 |
|  | 1490 | Broiler chickens | Pelicano et al., 2005 |
|  | 1640 | Broiler chickens | Awad et al., 2008 |
|  | 1548 | Broiler chickens | Williams et al., 2008 |
|  | 1467 | Broiler chickens | Incharoen et al., 2010 |
|  | 1928 | Broiler chickens | Lee et al., 2010 |
|  | 1761 | Broiler chickens | Laudadio et al., 2012 |
|  | 870 | Broiler chickens | Nasrin et al., 2012 |
|  | 824 | Broiler chickens | Moghaddam & Alizadeh-Ghamsari, 2013 |
|  | 2058 | Broiler chickens | Chen et al., 2015 |
|  | 1156 | Broiler chickens | Lei et al., 2015 |
|  | 1973 | Broiler chickens | Yue et al., 2015 |
|  | 2058 | Broiler chickens | Bogucka et al., 2017 |
|  | 718 | Broiler chickens | Prakatur et al., 2019 |
|  | 1172 | Indigenous | Mabelebele et al., 2017 |
|  | 619 | Pullet 16 wk old | Li et al., 2018 |
|  | 1040 | 18 wk old males | Yamauchi et al., 2010 |
|  | 1480 | Laying hen | Praes et al., 2011 |
|  | 1309 | Laying hen | Ding et al., 2018 |
| **Broiler Mean = 1440 + (n = 14) SEM 135.4 μm**  |
| **Chickens Mean = 1357 + (19) 109.9 μm**  |
| **Laying hens Mean = 1394 + (2) 85.5 μm**  |
| **Jejunum** |  |  |  |
|  | 3180 | Broiler chickens | Iji et al., 2001 |
|  | 780 | Broiler chickens | Xu et al., 2003 |
|  | 1001 | Broiler chickens | Pelicano et al., 2005 |
|  | 790 | Broiler chickens | Hu and Guo, 2007 |
|  | 848 | Broiler chickens | Incharoen et al., 2010 |
|  | 821 | Broiler chickens | Lee et al., 2010 |
|  | 1161 | Broiler chickens | Laudadio et al., 2012 |
|  | 652 | Broiler chickens | Nasrin et al., 2012 |
|  | 848 | Broiler chickens | Moghaddam and Alizadeh-Ghamsari, 2013 |
|  | 1549 | Broiler chickens | Chen et al., 2015 |
|  | 692 | Broiler chickens | Lei et al., 2015 |
|  | 1055 | Broiler chickens | Wu et al., 2013 |
|  | 1455 | Broiler chickens | Yue et al., 2015 |
|  | 1549 | Broiler chickens | Bogucka et al., 2017 |
|  | 920 | Broiler chicken | Metzler-Zebeli et al., 2018 |
|  | 718 | Broiler chickens | Prakatur et al., 2019 |
|  | 866 | 9 week-old Lohmann dual purpose chickens | Alshamy et al., 2018 |
|  | 1128 | Indigenous | Mabelebele et al., 2017 |
|  | 385 | Pullet 16 wk old | Li et al., 2018 |
|  | 920 | 18 wk old males | Yamauchi et al., 2010 |
|  | 803 | Laying hen | Praes et al., 2011 |
|  | 946 | Laying hen | Cutrignelli et al., 2018 |
|  | 1045 | Laying hen | Ding et al., 2018 |
|  | 1149 | Laying hen | Moniello et al., 2019 |
| **Broiler Mean = 989 + (15) 78.9 μm excluding Iji et al., 2001 as exceeding SD x 10** |
| **Chickens Mean = 960 + (23) 59.0 μm excluding Iji et al., 2001** |
| **Laying hens Mean = 985 + (4) 73.7 μm** |
| **Ileum** |  |  |  |
|  | 541 | Broiler chickens | Xu et al., 2003 |
|  | 919 | Broiler chickens | Pelicano et al., 2005 |
|  | 947 | Broiler chickens | Chichlowski et al., 2007 |
|  | 614 | Broiler chickens | Awad et al., 2008 |
|  | 420 | Broiler chickens | Williams et al., 2008 |
|  | 760 | Broiler chickens | Lee et al., 2010 |
|  | 355 | Broiler chickens | Laudadio et al., 2012 |
|  | 1161 | Broiler chickens | Nasrin et al., 2012 |
|  | 1022 | Broiler chickens | Chen et al., 2015 |
|  | 415 | Broiler chickens | Lei et al., 2015 |
|  | 789 | Broiler chickens | Wu et al., 2013 |
|  | 734 | Broiler chickens | Yue et al., 2015 |
|  | 1022 | Broiler chickens | Bogucka et al., 2017 |
|  | 1075 | Broiler chickens | Kimiaeitalab et al., 2017 |
|  | 377 | Broiler chickens | Alshamy et al., 2018 |
|  | 1172 | Indigenous | Mabelebele et al., 2017 |
|  | 931 | 3 wk. old pullet | Kimiaeitalab et al., 2017 |
|  | 921 | Pullet 16 wk old | Li et al., 2018 |
|  | 540 | 18 wk old males | Yamauchi et al., 2010 |
|  | 630 | Laying hen | Deng et al., 2012 |
| **Broiler Mean = 743 + (15) 71.4 μm**  |
| **Chickens Mean = 721 + (20) 59.9 μm** |
| **Laying hens Mean = 630 (1) μm** |
| **Villus width μm** |  |  |  |
| **Duodenum** |  |  |  |
|  | 431 | Broiler chickens | Incharoen et al., 2010 |
|  | 681 | Broiler chickens | Awad et al., 2008 |
|  | 420 | Broiler chickens | Williams et al., 2008 |
|  | 123.3 | Broiler chickens | Nasrin et al., 2012 |
|  | 101.4 | Broiler chickens | Moghaddam and Alizadeh-Ghamsari, 2013 |
|  | 90.9 | Broiler chickens | Laudadio et al., 2012 |
|  | 172.8 | Broiler chickens | Chen et al., 2015 |
|  | 194.3 | Broiler chickens | Bogucka et al., 2017 |
| **Chicken Mean = 276.8 + (8) 74.9 μm** |
| **Jejunum** |  |  |  |
|  | 132 | Broiler chickens | Chichlowski et al., 2007 |
|  | 236 | Broiler chickens | Incharoen et al., 2010 |
|  | 161.3 | Broiler chickens | Laudadio et al., 2012 |
|  | 108.2 | Broiler chickens | Nasrin et al., 2012 |
|  | 92.8 | Broiler chickens | Moghaddam and Alizadeh-Ghamsari, 2013 |
|  | 65 | Broiler chickens | Pelicano et al., 2005 |
|  | 170.6 | Broiler chickens | Chen et al., 2015 |
|  | 218.8 | Broiler chickens | Bogucka et al., 2017 |
| **Chicken Mean = 148.1 + (8) 21.2 μm** |
| **Ileum** |  |  |  |
|  | 105.4 | Broiler chickens | Chichlowski et al., 2007 |
|  | 504 | Broiler chickens | Williams et al., 2008 |
|  | 85 | Broiler chickens | Incharoen et al., 2010 |
|  | 366.2 | Broiler chickens | Laudadio et al., 2012 |
|  | 137.9 | Broiler chickens | Nasrin et al., 2012 |
|  | 163.8 | Broiler chickens | Chen et al., 2015 |
|  | 151.3 | Broiler chickens | Bogucka et al., 2017 |
| **Chicken Mean = 216.2 + (7) 59.3 μm** |

**SUPPLEMENTARY TABLE 10.** Small intestine morphometric parameters in mallards and domestic ducks

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
|  | Duodenum  | Jejunum | Ileum |  |
| Villus height |
| Mallards | 1000 |  |  | Kenyon et al., 2004 |
|  |  |  |  |  |
| Domesticated ducks | 660 |  |  | Kenyon et al., 2004 |
|  | 887 | 847 | 643 | Jiang et al., 2012 |
|  | 700 | 799# | 898 | Wang et al., 2018 |
|  | 1087 | 939 | 699 | Ran et al., 2020 |
| Mean  | 891 + (5) 111.7 | 862 + (3) 41.1  | 747 + (3) 77.4 |  |
| Mucosal thickness | 1003 | 898# | 793 | Wang et al., 2018 |
| Small intestine  | 107 cm kg-1 | Jiang et al., 2012 |
| Small intestine | 70.8 cm kg-1 | King et al., 2000 |

# mean of duodenum and ileum

**SUPPLEMENTARY TABLE11.** Lengths/height (in μm) of villi in the small intestine in mammals

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| Species | Duodenum | Jejunum | Ileum | Reference |
| Human *(Homo sapiens*)  | 704 |  |  | Hasan and Ferguson, 1981 |
| African green monkey (*Chlorocebus aethiops*) | 605 | 663 | 398 | Paulini et al., 2006 |
| Common shrew (Sorex araneus) | 416 | 442 | 356 | Jaroszewska and Wilczyńska, 2006 |
| Guinea pig (*Cavia porcellus*) |  | 579 |  | Weaver and Carrick, 1989; Mitjans, and Ferrer, 2004 |
| Ground squirrel (*Spermophilus tridecemlineatus*) |  | 529 |  | Carey, 1990 |
| Persian squirrel (*Sciurus anomalus*) | 297 | 208 | 203 | Tootian et al., 2013 |
| House mouse(*Mus musculus*) | 386 | 346 | 156 | Short and Derrickson, 2020 |
| Cattle (*Bos taurus*) | 855 | 862 | 583 | Zitnan et al., 2008; Kvidera et al., 2017 |
| Brown rat (*Rattus norvegicus*) | 504 | 416 | 247 | Gardner and Steele, 1989; Seyyedin and Nazem, 2017 |
| Dog (*Canis lupus*)  | 739 | 653 | 572 | Verma et al., 1968; Kuzmuk et al., 2005 |
| Pig (*Sus scrofa*) | 663 | 588 | 447 | Kitt et al., 2002; Chwen et al., 2013 |

**SUPPLEMENTARY TABLE 12.** Absorption area in avian model species and various mammalian species

|  |  |  |  |
| --- | --- | --- | --- |
| **Species** | **Absorptive area in m2 [cm2 x 104]** | **Absorptive area of small intestine in m2 kg-1** | **Reference** |
| **Birds** |  |  |  |
| Chicken | 7.78 | 4.86 | Calculated from Ferrer et al., 1995; Mitjans et al., 1997 |
| Mallard | 5.67 | 7.80 | Watkins et al., 2004 |
| **Mammals** |  |  |  |
| Human (*Homo sapiens*) | 30 | 0.48 | Helander and Fändriks, 2014 |
| Mouse (*Mus musculus*) | 1.105 | 31.5 | Ferraris et al., 1989; Casteleyn et al., 2010 |
| Bat species 1 | 5.42 | 44.4 | Ferraris et al., 1989 |
| Bat species 2 | 29.4 | 47.1 | Ferraris et al., 1989 |
| Rat (*Rattus norvegicus*) | 1.8 | 4.85 | Ferraris et al., 1989 |
| Rabbit (*Oryctolagus cuniculus*) | 12.1 | 5.48 | Ferraris et al., 1989  |
| Dog (*Canis lupus*) | 39.9 | 3.41 | Ferraris et al., 1989 |
| Desert wood rat (*Neotoma lepida*) | 4.1  | 12.2d | Ferraris et al., 1989 |
| **Reptiles** |  |  |  |
| Desert iguana (*Dipsosaurus dorsalis*) | 0.444 | 0.070 | Ferraris et al., 1989 |

**SUPPLEMENTARY TABLE 13.** Bile production in the chicken and multiple mammalian species

|  |  |  |
| --- | --- | --- |
| Species | Bile flow mL h-1 kg b.w.-1 | Reference |
| ChickenM  | 4.2 | Hurwitz et al., 1973 |
| Chicken | 0.702 | Sturkie, 1976 cited by Duke, 1986 |
| ChickenN | 0.456 | Lisbona et al., 1981 |
| ChickenO  | 0.726 | Pullen and Polin, 1984 |
| Chicken | 0.612 | Dukes et al., 1987 |
| Chicken | 0.246 | Dukes et al., 1988 |
| Mean  |  |  |
| **Mammals**  |
| DogP | 0.6 | Boyer, 1986; 2013 |
| HumanQ | 0.347 | Boyer and Bloomer, 1974; Boyer, 1986; 2013; Hundt et al., 2019 |
| MonkeyR | 0.9 | Boyer, 1986; 2013 |
| MouseS | 3 | Bodewes et al., 2015 |
| PigT | 1.383 | Sambrook, 1981; Martínez et al., 2018 |
| RabbitV | 5.4 | Boyer, 1986; 2013 |
| RatX | 4.23 | Boyer, 1986; 2013; Johnson et al., 2002 |
| Sheep | 0.410 | Harrison, 1962 |
| Syrian hamster (*Mesocricetus auratus*) | 2.04 | Robins and Fasulo, 1973 |

M Assumes body weight of 1.5 kg

N Fasted chicken with a mean weight 3.2 kg

O Body weight assumed as 1.8 kg for 8-week old meat type chicken based on National Chicken Council (<https://www.nationalchickencouncil.org/about-the-industry/statistics/u-s-broiler-performance/>)

P Assumes body weight of 15 kg

Q Assumes body weight of 80 kg

R Assumes body weight of 25 kg

S Assumes body weight of 26 g

T Body weight 27.5 kg

V Assumes body weight of 3 kg

X Assumes body weight of 0.3 kg

**SUPPLEMENTARY TABLE 14.** Weights and blood flow to components of the oviduct together with blood flow to the ovary

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| Component  | Weight | Blood flow mL min-1 | Blood flow mL min-1 g-1 | References |
| **Infundibulum** |  |  |  |  |
|  | 2.7 |  | 0.352 | Boelkins et al., 1973 |
|  |  | 0.95 |  | Moynihan and Edwards, 1975 |
|  | 3.0 | 0.73 | 0.243 | Niezgoda et al., 1979  |
|  | 2.2 | 0.98 | 0.445 | Wolfenson et al., 1981 |
|  | 2.3 | 0.989 | 0.430 | Niezgoda et al., 1982 |
|  |  | 0.95 |  | Scanes et al., 1982 |
|  |  | 1.11 |  | Hrabia et al., 2005 |
|  |  | 1.32 |  | Rząsa et al., 2008 |
| **Mean + (n =) SEM** | **2.55 + (4) 1.18**  | **0.95 + (7) 0.05** | **0.37 + (4) 0.05** |  |
|  |  |  |  |  |
| **Magnum** |  |  |  |  |
|  | 26.2 | 19.7 | 0.752 | Boelkins et al., 1973 |
|  | 20.8 | 4.57 | 0.220 | Moynihan and Edwards, 1975 |
|  | 23.4 | 2.24 | 0.096 | Niezgoda et al., 1979 |
|  | 29.4 | 21.3 | 0.724 | Wolfenson et al., 1981 |
|  | 18.1 | 7.78 | 0.430 | Niezgoda et al., 1982 |
|  |  | 11.25 |  | Scanes et al., 1982 |
|  |  | 10.5 |  | Hrabia et al., 2005 |
|  |  | 9.1 |  | Rząsa et al., 2008 |
| **Mean + (n =) SEM** | **23.6 + (5) 1.98** | **10.8 + (8) 2.37** | **0.44 + (5) 0.13** |  |
|  |  |  |  |  |
| **Isthmus** |  |  |  |  |
|  | 5.9 | 3.6 | 0.610 | Boelkins et al., 1973 |
|  | 4.4 | 3.43 | 0.780 | Moynihan and Edwards, 1975 |
|  | 4.2 | 1.14 | 0.271 | Niezgoda et al., 1979 |
|  | 7.8 | 3.8 | 0.487 | Wolfenson et al., 1981 |
|  | 3.9 | 1.599 | 0.410 | Niezgoda et al., 1982 |
|  |  | 1.57 |  | Scanes et al., 1982 |
|  |  | 2.60 |  | Hrabia et al., 2005 |
|  |  | 2.46 |  | Rząsa et al., 2008 |
| **Mean + (n =) SEM** | **5.24 + (5) 0.73** | **2.52 + (5) 0.36** | **0.511 + (5) 0.09** |  |
|  |  |  |  |  |
| **Uterus** |  |  |  |  |
|  | 9.85 | 19.7 | 2.00 | Boelkins et al., 1973 |
|  | 9.95 | 14.53 | 1.460 | Moynihan and Edwards, 1975 |
|  | 10.2 | 3.37 | 0.330 | Niezgoda et al., 1979 |
|  | 15.4 | 30.8 | 2.00 | Wolfenson et al., 1981 |
|  | 12.3 | 7.8 | 0.634 | Niezgoda et al., 1982 |
|  |  | 8.55 |  | Scanes et al., 1982 |
|  |  | 7.03 |  | Hrabia et al., 2005 |
|  |  | 7.52 |  | Rząsa et al., 2008 |
| **Mean + (n =) SEM** | **11.54 + (5) 1.06** | **12.4 + (8) 3.18** | **1.28 + (5) 0.35** |  |
|  |  |  |  |  |
| **Vagina** |  |  |  |  |
|  | 4.0 | 1.16 | 0.29 | Moynihan and Edwards, 1975 |
|  | 3.5 | 0.77 | 0.22 | Niezgoda et al., 1979 |
|  | 3.3 | 1.06 | 0.321 | Niezgoda et al., 1982 |
| **Mean + (n =) SEM** | **3.60 + (3) 0.21** | **1.00 + (3) 0.12** | **0.28 + (3) 0.03** |  |
|  |  |  |  |  |
| **Ovary** |  |  |  |  |
|  |  | 6.92 |  | Moynihan and Edwards, 1975 |
|  |  | 5.18 |  | Niezgoda et al., 1979 |
|  |  | 5.79 |  | Wolfenson et al., 1981 |
|  |  | 23 |  | Niezgoda et al., 1982 |
|  |  | 3.06 |  | Scanes et al., 1982 |
| **Mean + (n =) SEM** |  | **8.79 + (5) 3.06** |  |  |

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