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LOCOMOTOR MECHANISMS OF BIRDS

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FRANK A. HARTMAN

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INTRODUCTION

Ornithological literature abounds in descriptions of the habits and activities of birds, while anatomical studies are less common and are related mostly to taxonomy. Attempts to correlate structure with function in birds are few, yet this is a very intriguing subject for study since birds are among the most active members of the animal kingdom. This is reflected in their high rate of metabolism and elevated temperature. Their versatility is great; they can fly, run, or swim, some performing all these activities, while others are limited to one or two. However, certain species excel in locomotion in the air, on the land, or in the water.

We note the explosive flight of the grouse, the graceful glide of the swallow, the soaring of the vulture, the poise of the hummingbird, the racing of the roadrunner, and the diving of the loon. Their skill can be seen, their speed can be measured, but the relative power involved escapes us.

Actual measurement of these activities is necessarily limited, since the confinement required would defeat its goal, but the muscles can be weighed as an indication of their potential capacity. The flight muscles can serve as a measure of power in the air. Likewise muscles of the lower extremities represent the power for terrestrial or aquatic locomotion, while heart weights bear a direct relation to the ability to sustain activity. The areas of the wings, tail, and total gliding surface are measures of the airlift, and the relation of length to breadth of the wing shows the adaptation for lift or glide. The superficial and deep layers of the pectoralis, which constitute 48 to 68 percent of all flight muscles, are most essential in depressing the wing or lifting the body, while the supracoracoideus raises the wing. The remainder of the flight muscles (grouped in the master list, table 1 (pp. 38-87), under the heading "Rest") play their part in controlling wing movement.

Little accurate information about the relative size of muscles has been available. General statements have been made such as that by

Aymar (1935, p. 57): "a pigeon's pectoral muscles which raise and lower the wing are as much as 50 percent of the entire bird." However, Fisher (1946) made careful comparisons of the volumes of the individual locomotor muscles of vultures preserved in alcohol. For the present study I selected certain groups of muscles used in locomotion and weighed them in the fresh condition. In addition, the areas used in lift or glide have been determined.

METHODS

All specimens were kept in waterproof plastic bags to prevent drying until weighed at the field station. Small birds were weighed on a torsion balance of 120 grams' capacity. Larger ones were weighed on Chatillon spring balances, the most sensitive one for the weight involved being used: 6,000 grams' capacity with 24 grams' sensitivity; 500 grams' capacity with 10 grams' sensitivity; and 250 grams' capacity with 5 grams' sensitivity.

The bird was spread out on a sheet of paper tacked to a drawing board. A careful outline of the spread wings, tail, and body was traced. The length and median width of the wing were also determined for the calculation of the aspect ratio $\left(\frac{L}{W}\right)$. Areas were obtained later by a compensating polar planimeter. The buoyancy index was calculated by the formula, $\frac{\sqrt[2]{\text{wing area}}}{\sqrt[3]{\text{body weight}}}$, since area is two-dimensional and weight is three-dimensional (George and Nair, 1952). After skinning the areas involved, the pectoralis superficialis, supracoracoideus, the rest of the flight muscles (called "rest") except those along the carpus, metacarpus, and phalanges, and finally all the muscles of the lower extremities were removed by means of scalpel and scissors and then weighed. (If there was any delay before weighing, the dissected muscles were kept in a moist chamber.) These muscles were weighed on both sides from at least 200 birds, but thereafter the muscles on one side only were weighed, since the two sides proved to be identical within the limits of error of dissection. The weights of smaller muscle groups have been determined in a few species. Thus the shoulder, upper and lower arm, and upper and lower leg muscles have been separated. Doubling these values gave the totals used in calculations.

Heart vessels were trimmed close to the organ and both sides cut open, any remaining blood being removed by contact with blotting paper. Weighing was carried out on the torsion balance or on a

Roller-Smith balance with a capacity of 1,500 milligrams and a sensitivity of 0.02 milligram. Only healthy adult birds were used, except for a few immature specimens which are mentioned in the text. Nomenclature is based largely on Peters' check list (1931-1951) and on the check list of the American Ornithologists' Union (1957) for North American passerine species. The values obtained were listed in tables. In our earlier work some of the muscles were not weighed, which accounts for the lack of complete data in some species. The text figures make comparison of typical values in each family, those preceded by an asterisk in the table being represented.

Material for this work was collected in Florida, Maine, Ohio, and Panamá. Panamanian birds were collected during the period January through March at the following stations: Juan Mina, Canal Zone, on the Río Chagres; Río La Jagua in the Pacora marshes, in the Province of Panamá east of Panama City; Cerro Copete (elevation 7,000 ft.) above Boquete, and the finca "Palo Santo" near the village of El Volcán (4,250 ft. above sea level), in the Province of Chiriqui. Florida birds were collected at different seasons on Lake Okeechobee, around the islands of the Gulf Coast, and on the prairies and hammocks of the peninsula. Ohio birds were obtained from the central part of the State, and Maine birds were collected at or near Lake Kezar in the southwestern part of the State. Most specimens were obtained in the morning before 11 o'clock.

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I am very much indebted to Richard Archbold, of the Archbold Biological Station, Florida, for his personal assistance in the collection of material, and for the use of the facilities of the Station. In Panamá the studies in the Canal Zone were based at the Juan Mina Field Station of the Gorgas Memorial Institute through the good offices of Dr. Carl Johnson, the director. The La Jagua Hunt Club permitted the use of their facilities for work in the open country near the Río La Jagua. Pablo Brackney kindly granted our party the use of a cottage at "Palo Santo," and the late Tollef Mönniche aided us on our expeditions on Cerro Copete above Boquete. Alois Hartmann also permitted us to stay at his place in western Chiriquí. The late Dr. James Zetek, then Resident Manager of the Canal Zone Biological Area on Barro Colorado Island, was very helpful at all times with advice. I wish to thank Dr. Alexander Wetmore for the identification of some of the Panamanian birds and for a critical reading of the manuscript. Many of the measurements and calculations were carried out by Carl Albrecht, Kent Bruno, Barbara Caldwell, David Gillespie, Elmer E. Hartman, Donald Neal, and Kenneth Teague. This study was aided by grants from the Comly-Coleman Fund and the Graduate School of the Ohio State University.

RESULTS

Data on more than 360 species in 70 families are included in this report. The muscle weights are calculated as percent of body weight. The wing and other areas are given as $cm.^2$ per gram of body weight. Glide area is the area included in wings, tail, and body.

In the master list (table 1, pp. 38-87) the number of individuals in a species is shown in parentheses, with the mean values and standard error of the means, or the individual values are given if less than three. Sexes are separated for body weights and for other determinations where the differences between sexes are significant; otherwise the data of the two sexes are combined. Although the data from a single individual may not be representative of a species, they have been included if the species is sufficiently interesting.

Before embarking on a consideration of the muscles I wish to call attention to certain species in which there is a significant difference in body weight between the sexes. Those in which males are larger are: *Podiceps dominicus, Casmerodius albus, Gallus gallus, Aramus guarauna, Porphyrula martinica, Columba speciosa, Brotogeris jugularis, Crotophaga major, Crotophaga ani, Crotophaga sulcirostris, Nyctidromus albicollis,* many trochilids, *Centurus rubricapillus, Centurus chrysauchen, Dendrocincla homochroa, Sittasomus griseicapillus, Xiphorhynchus guttatus, Anabacerthia striaticollis, Manacus vitellinus, Fluvicola pica, Cyanocitta cristata, Parus carolinensis, Parus bicolor, Parula pitiayumi,* many icterids, and *Arremonops conirostris.* In the following species the females are larger: *Jacana spinosa, Tyto alba, Speotyto cunicularia, Cotinga ridgwayi, Corapipo leucorrhoa, Thryothorus modestus,* and *Selasphorus scintilla.*

Let us now consider the distinctive values in each family and their possible relation to habits (table 1).

Tinamidae.—The tinamous are most unusual birds, possessing extremely large flight muscles (37 to 40 percent of the body weight, of which the pectoralis is 63 percent) and large leg muscles (13 to 17 percent) but the smallest heart (0.19 to 0.25 percent) of all birds. The pectorals are so large that they extend beyond the keel of the sternum. In *Crypturellus* the sternum is submerged 7 to 8 mm. below the bulging pectorals. The same condition is present in *Nothocercus* and in *Tinamus,* where the submergence may reach 9 to 10 mm. The wings are small (buoyancy index, 2.86 to 3.14) and broad (aspect ratio, 1.49 to 1.62). The wing area per gram of flight muscles is 19 $cm.^2$ in *Tinamus* and 36 $cm.^2$ in *Crypturellus. Nothocercus* possesses smaller pectoralis muscles ($P<0.01$) but larger lower-extremity muscles than *Tinamus* and *Crypturellus.* The muscles are in keeping with the habits—these birds run along the ground or fly explosively for short distances, the small heart preventing more prolonged effort.

Podicipedidae.—Grebes are most proficient in swimming and diving, using their feet in the process (Van Tyne and Berger, 1959). Their flight muscles are very small, being only 14 percent of the body in *Podiceps dominicus.* This species, which weighs only a little more than one-third as much as *Podilymbus podiceps,* possesses almost double the wing area of the latter. *Podiceps dominicus* also has a lower aspect ratio (2.51 compared to 2.91). The tails are insignificant in both species. The leg muscles are large, being 16 percent in *Podiceps* and 18 percent in *Podilymbus.* The leg position is ideal for swimming but causes an awkward waddling gait in walking. The heart is moderate in size in both species (1.00 to 1.05 percent).

Pelecanidae.—The clownish brown pelican starts rather awkwardly with slow, sweeping wing strokes, continuing with frequent soaring and sailing or, on a gentle breeze, gliding gracefully just above the water. The male has relatively larger flight and leg muscles than does the female, but compared to the cormorant, the flight muscles are but a little larger while the legs are less than half the size. His wings are moderately large (1.34 $cm.^2$ per g. of body; buoyancy index, 4.38) but very long (aspect ratio, 3.75), enabling him to skim over the water with ease.

Phalacrocoracidae.—The cormorant prefers to dive and swim, since that is his method of obtaining food. He is a rapid swimmer, using only his feet according to Selous (see Bent, 1922), holding his wings motionless. In the air he is a heavy flier (flight muscles, 17 percent; buoyancy index, 3.27), slowly flapping his wings after the manner of a heron. His legs are large (muscles are 11 percent of the body), but because of their position, on land he is awkward, though less helpless than the grebe.

Anhingidae.—The anhinga, like the cormorant, obtains his food by diving and swimming, using his feet only, with wings slightly folded or slightly expanded and steering with his tail, which can be spread as a rudder (Bent, 1922). However, unlike the cormorant he is a graceful, rather powerful flier, having somewhat larger flight muscles (19 percent) and wings (buoyancy index, 3.7) but smaller legs (8.6 percent).

Fregatidae.—The man-o'-war, one of the most graceful birds in the air, soars much of the time, steering by his scissors tail, but he can also fly rapidly to overtake another bird. His wings are very large (buoyancy index, 5.55) and extremely long (aspect ratio, 3.5 to 4.4), but his pectoralis plus supracoracoideus muscles are moderate (13 to 17 percent).

Ardeidae.—The large leg muscles of the herons are useful for wading and stalking prey. The members of this family show a considerable range in equipment, but the wings of all are rather long (aspect ratio, 2.00 to 2.66) and large (buoyancy index, 3.68 to 5.28), and all have large flight muscles (20 to 25 percent) except *Ixobrychus* (13.89 percent).

They vary as much in flight as in muscular equipment. Some, like the great blue heron, make an awkward start on the takeoff by vigorous wing strokes, but once underway the long, slow strokes carry them majestically through the air. The black-crowned night heron differs from other herons in having a flight more gull-like, being stronger and swifter with quicker wing strokes. This is not due to the size of the wing muscles, since they are no larger. The least bittern has an awkward fluttering flight for a short distance, preferring to escape by walking or climbing. However, on long flights he appears strong and rather swift despite small flight muscles. The hearts of all herons are rather small (0.57 to 0.83 percent).

The hearts of the Florida subspecies of *Butorides virescens* are heavier ($P<0.05$) than those of the same species collected in Panamá. This is also true for individuals of *Florida caerulea* and *Ixobrychus exilis* from the two localities. The hearts ($P<0.01$) and pectoral and supracoracoideus muscles ($P<0.05$) of *Tigrisoma lineatum* are larger than the same features in *Heterocnus mexicanus*.

Cochleariidae.—The boat-billed heron is similar to the true herons in the size of its flight equipment. It is interesting to note that in an immature *Cochlearis,* at a time when the body had almost attained adult weight, the flight muscles were less than half the weight of those in the adult, while the leg muscles were nearly the weight of the adult's. The heart of the immature was also very much smaller than that of the adult. The early development of the leg muscles was also shown in a young *Heterocnus mexicanus* (250 g.). In this bird the legs were half-grown (muscles 5.88 percent of the body) while the flight muscles were little more than one-tenth the value of those of the adult (2.28 percent). Likewise, an immature male *Podilymbus podiceps* that had attained the weight of the adult (450 g.) possessed flight muscles (7.58 percent) somewhat less than those of the adult, while the legs were the size of those of the adult (18.9 percent). The wing feathers were just emerging.

Ciconiidae.—The wood ibis springs powerfully into the air and flies higher and higher until almost out of sight, when he sails gracefully on motionless wings in wide circles. His flight muscles are somewhat larger (27 percent of body) and his wings narrower (aspect ratio, 2.85) than in most herons, but his legs are about the same size (10.9 percent).

Threskiornithidae.—The white ibis walks and climbs nimbly and swims well. He flies with strong, rapid strokes, varied with occasional periods of sailing. There is nothing unusual about his measurements.

Anatidae.—Both the pintail (*Anas acuta*) and blue-winged teal (*Anas discors*) are fast fliers with fairly large hearts (1.23 and 1.15 percent respectively) and large flight muscles (31.36 and 29.2 percent). They spring upward from the water and get underway at once. The whistling of the teal's wings is probably due to the rapid wing beats, since the wings are small for the weight (buoyancy index, 2.84). The lesser scaup (*Aythya affinis*), a rather laborious but steady flier, has a buoyancy index of 2.62. Its heart is smaller than that of *Oxyura dominica* ($P<0.05$) and *Anas acuta* ($P<0.01$). The heart of *Cairina,* in the domesticated form, is smallest of all. The flight muscles of the male *Cairina* are smaller ($P<0.01$) than those of the female, while the reverse is true for the legs. The supracoracoideus in ducks is about one-third that of the "rest" group. *Cairina* possesses the largest legs of all ducks studied.

Cathartidae.—The flight of *Coragyps* is inferior to that of *Cathartes.* He has smaller wings ($P<0.01$) and flight muscles ($P<0.05$) a larger heart and legs ($P<0.01$,), and broader wings. Differences are also shown between Panamá and Florida vultures. The hearts of Florida *Coragyps* ($P<0.05$) and *Cathartes* ($P<0.01$) are larger than those of the Panamá species.

Accipitridae.—Among the hawks, *Elanoïdes* is unsurpassed in beautiful maneuverings. With his long wings (aspect ratio, 3.40) and forked tail he soars aloft to sport among the clouds. The speedy accipiters fly by a series of quick flappings followed by short periods of rapid sailing. In contrast the *Buteo* flight is heavy but powerful and graceful. *Buteogallus anthracinus* is similar in flight.

The hearts of the Accipitridae are relatively small, ranging from 0.40 to 0.81 percent. The flight muscles of most of them are of moderate size, *Chondrohierax* and *Spizaëtus* being exceptions. The most striking finding is the relatively small size of the supracoracoideus (only 0.39 to 0.56 percent of the body). The legs, except in *Elanoïdes,* are fairly large, and the wings are fairly long. These characteristics indicate good fliers but little ability to sustain activity for long periods, unless by soaring. The muscles of the lower extremities of many hawks are relatively large, and those of the upper extremities are not small. Several hawks are strong fliers, although they frequently soar.

Pandionidae.—The muscles of the osprey resemble those of the Accipitridae, but the legs are smaller and the heart is larger than in most of the latter.

Falconidae.—The hearts of falcons are a little larger than those of hawks, ranging from 0.53 percent (*Micrastur*) to 1.11 percent (*Polyborus*). The supracoracoideus is also somewhat larger than in hawks. The wings are narrower in species that are fast fliers. The flight and leg muscles of *Micrastur semitorquatus* are larger than those of *Micrastur ruficollis,* while the wings are much smaller; yet the buoyancy index is about the same.

Cracidae.—In the Cracidae, represented in our study by the chestnut-winged chacalaca (*Ortalis garrula*) and the black guan (*Chaemepetes unicolor*), the flight muscles are moderately large (23 to 26 percent), with the supracoracoideus of fair size (2 to 3 percent). These birds are heavy fliers with wings rather moderate in size (buoyancy index, 3.66) and broad (aspect ratio, 1.38 to 1.51); the leg muscles are large (15.7 to 20 percent), while the heart is small (0.48 to 0.62 percent).

Phasianidae.—The phasianids are very interesting. Three species of quail, natives of widely different parts of the world, possess very large flight muscles (*Coturnix,* 25.6 percent; *Odontophorus,* 29.4 percent; *Colinus,* 34.3 percent) and large supracoracoideus (5.66 percent; 5.89 percent; 7.16 percent), with a "rest" nearly the size of the latter (4.46 percent; 6.17 percent; 5.53 percent). But the heart of *Coturnix* is about three times the size of that of the other two species (1.00 percent compared to 0.34 percent and 0.38 percent). The lower extremities are large (muscles 12.16 percent, 16.38 percent, and 14.6 percent), but the wings are small (buoyancy indices, 2.38, 3.10, 2.62). It should be noted that the aspect ratio of *Coturnix* is higher than that of other phasianids (2.15 as compared with 1.56 and 1.74). The powerful musculature for flight indicates great bursts of speed although the species with small hearts would have limited endurance. *Coturnix,* with a larger heart, can sustain the flight required in its long migrations. In the domesticated *Gallus gallus* (white leghorn) the flight muscles and wings are much smaller than in the quail; otherwise the values are similar. However, the males are much larger than the females and have larger legs ($P<0.01$) and hearts ($P<0.01$). Our specimens of *Coturnix* were raised in captivity, but they have not been subjected to selective breeding as has *Gallus.*

Numididae.—*Numida meleagris,* although domesticated, has values similar to those for some of the quails except that the heart is about twice the size and the wings are somewhat smaller.

Aramidae.—The limpkin (*Aramus guarauna*), a slow and infrequent flier, alternating wing beats with sailing, has fairly large flight muscles (21 to 24 percent), wings with a buoyancy index of 3.59, and large leg muscles (16 percent). Like the rail, he can travel rapidly on the ground. His wings are fairly long (aspect ratio, 2.2 to 2.9).

Rallidae.—Many rails dive and swim readily but fly feebly, and after a short flight, drop to the ground and run swiftly. Thus their flight muscles are small (12 to 17 percent), and their hearts are moderate in size, ranging from 0.58 to 0.65 percent. In most species the legs are large, especially so in *Aramides cajanea* (24.8 percent). An immature *Laterallus albigularis* weighing 20.75 grams possessed a heart 0.70 percent of body, a pectoralis of only 0.61 percent (adult 7.0 percent), and lower extremity muscles of 2.51 percent (adult 17.4 percent). The flight of the purple gallinule (*Porphyrula martinica*) ordinarily seems weak and labored, but on long flights it is fairly swift. Both gallinules run with great speed. The coot (*Fulica americana*) is a more vigorous flier than the gallinules.

Heliornithidae.—The finfoot (*Heliornis fulica*) resembles the rail in all his proportions. He swims much and dives to escape, although he is a fairly strong flier for short distances. A young female weighing 76.05 grams possessed a heart 0.68 percent of the body, flight muscles only 8.07 percent compared to 17.64 percent for the adult, and lower extremities 9.31 percent of body (adult, 15 percent).

Jacanidae.—The jaçana, which spends much time running over lily pads, swimming if need be, has leg muscles somewhat smaller than those in rails (10 to 12 percent). He hovers much in flying, using his rather large wings (buoyancy index, 3.64).

Charadriidae.—The plovers are swift runners and strong fliers. Such activity is supported by a large heart (1.36 percent), large flight muscles (29 percent), and lower extremities of moderate size (7.88 percent).

Scolopacidae.—Likewise, the sandpipers, as they run up and down the beach or fly swiftly to new hunting grounds, use a fairly large flight apparatus (flight muscles, 23 to 32 percent and hearts, 1 to 1.54 percent) and small to moderate lower extremities (4.5 to 9 percent).

Recurvirostridae.—The birds in this group are similar to the other shore birds, being equipped for strong flight.

Laridae.—The flight apparatus of gulls and terns differs in conformity with their respective habits. The slow-flying gulls, which soar much, possess rather small hearts (0.85 percent), moderate flight muscles, and moderate lower extremities (5 to 6 percent), while the more active terns, which dash about and dive for fish, have larger hearts (0.84 to 1.08 percent), flight muscles about the same, and lower extremities only half the size of those in gulls.

Rynchopidae.—Skimmers are almost identical with terns with respect to their equipment; they are swift and dextrous as they plow the surface of the water for food.

Columbidae.—Doves and pigeons can be divided into two groups according to heart size. In one group hearts range from 0.28 to 0.56 percent of the body; in the other, from 0.93 to 1.29 percent. Those of the first group are *Leptotila cassini, Leptotila rufinucha, Geotrygon costaricensis* and *Geotrygon chiriquensis,* while all other species including *Leptotila verreauxi,* are in the second group. We are unable to explain the differences between the two species of the genus *Leptotila.* The contrast in muscle values between *Leptotila cassini* and *Leptotila verreauxi,* both collected at sea level, is striking. The heart of *verreauxi* is larger ($P<0.01$), while the pectoral muscles of *cassini* are larger ($P<0.01$). The heart of *Columbigallina passerini* of Florida is larger than that of *Columbigallina talpacoti* ($P<0.05$) of Panamá; the heart of *Claravis pretiosa* is larger ($P<0.01$) than that of *Claravis mondetoura.* The flight muscles of all pigeons are almost as large in proportion (31 to 44 percent) as those in tinamous, and the supracoracoideus is as large or nearly as large as the "rest" group. The wings are quite large (buoyancy ratio, 3.0 to 3.65), the legs small to moderate (4.5 to 7.8 percent). Both the wild and domesticated species of *Columba* are powerful long-range fliers, while *Columbigallina* flies but short distances.

Psittacidae.—Parrots are usually strong fliers and make good use of their legs. The female *Brotogeris* is larger than the male. All have fairly large hearts (1.03 to 1.52 percent) and large flight muscles (25 to 28 percent). The supracoracoideus is one-third to one-half of the "rest" group. Wings of fair size give them a buoyancy index of 3.2 to 3.7, and the lower extremities are of medium size (5.5 to 7.8 percent). The proportions of domesticated *Melopsitticus* are similar to those of the wild forms except that the buoyancy index is lower (2.84).

Cuculidae.—Some cuckoos fly very little, and we have studied only those that do more flying. In these, the power of flight varies considerably. The hearts (0.50 to 0.94 percent) indicate little staying power. The flight muscles are very moderate (14 to 20 percent), supporting wings of a high buoyancy index (3.7 to 4.4) and a low aspect ratio (1.3 to 1.8), enabling them to fly only slowly. The tails are large, and the lower extremities are of considerable size (muscles, 7 to 15 percent). Anis fly with a series of steady wing beats alternating with short sails. The flight resembles somewhat that of the Florida jay, being slow and gliding and rather labored. The hearts and flight muscles are smaller in *Piaya cayana* ($P<.01$) and *Crotophaga ani* ($P<0.01$) in specimens collected at sea level than in the same species collected at 4,300 feet elevation.

Tytonidae.—The barn owl (*Tyto alba*) may be grouped with the typical owls with respect to muscle values, although he has a larger wing than most of the others.

Strigidae.—Owls are able to fly quietly, as their wings are soft, very large (buoyancy index, 4.24 to 5.11), and broad (aspect ratio, 1.8 to 2.7). The flight muscles are moderately powerful (19 to 27 percent), and the hearts are small to medium (0.31 to 0.89 percent), the largest being found in the burrowing owl (*Speotyto cunicularis*).

Nyctibiidae.—The wings of the Nyctibiidae and Caprimulgidae are as large as, or larger than (buoyancy index, 4.36 to 5.19), those of owls but with a very high aspect ratio (2.20 to 3.4). The smaller heart (0.58 percent) of the potoo (*Nyctibius griseus*) is in keeping with his more limited activity, since he makes but short flights in his forays for insects, in contrast with the caprimulgids (0.78 to 1.12 percent), which sweep the air in sustained flight.

Caprimulgidae.—The pauraque (*Nyctidromus albicollis*), with a longer tarsus and larger leg muscles (8.28 percent) than some other caprimulgids, is more active on its feet and can run swiftly.

Trochilidae.—The hummingbird is the acrobat among birds—none equals him in speedy maneuverability. He hovers and flies forward or backward at will. Of his large flight muscles, the pectoralis plus the supracoracoideus constitute a large proportion. Many species show sex differences, and in these species the muscles of the male are always larger than those of the female. Never has the reverse been found in the 25 species that I have examined. This sex difference applies to the heart in several species, and in *Amazilia edward, Amazilia tzacatl, Lampornis castaneoventris,* and *Selasphorus scintilla* it applies to the heart and pectoralis-supracoracoideus. Hearts range from 1.65 to 3.25 percent of the body, pectoralis-supracoracoideus from 21.7 to 33.1 percent. The supracoracoideus, ranging from 6.6 to 12.2 percent, is the largest of all birds studied. The "rest" is small, ranging from 1.75 to 4.79 percent, and leg muscles are very small, being only a little more than 1 percent. Wings range from 3.11 to 5.70 $cm.^2$ per gram; tail from 1.57 to 2.95 $cm.^2$ per gram; and buoyancy index from 1.31 to 3.09.

Trogonidae.—Trogons make short, rapid flights among the trees to catch insects. Their flight muscles (29 to 32 percent) are slightly larger than those of nightjars. Their hearts are also larger (1.05 to 1.29 percent), but the wings are smaller (buoyancy index, 3.68 to 3.91) and much wider (aspect ratio, 1.9 to 2.1) for flight among foliage. Like the nightjars, their legs are small (2.4 to 3.1 percent). The wings and glide areas of *Pharomachrus, Trogon massena,* and *Trogon melanurus* are smaller than those of the other three species of trogons measured.

Alcedinidae.—The fairly large wings (buoyancy index, 3.09 to 3.68) enables the kingfisher to fly swiftly in short flights. The hearts of these birds are large, especially in the smaller species (1.02 to 1.35 percent). The flight muscles (24.5 to 26 percent) are about the size of those in the nightjars, and the legs are small (2.48 to 3 percent).

Momotidae.—Motmots perch for long periods in one place (lower extremities 6 percent). Their flight is undulating, their wings are large (buoyancy index, 3.85) and broad (aspect ratio, 1.70), and they have long, ornamental tails. The small hearts are indicative of limited activity (0.39 to 0.49 percent).

Bucconidae.—Although most species of puffbirds are sedentary, they sally forth occasionally to capture insects (flight muscles, 24 to 28 percent; buoyancy index, 3.4 to 3.56). Their lower extremities are of moderate size (4 percent), and their hearts are small 0.45 to 0.58 percent).

Capitonidae.—Barbets are weak fliers (flight muscles, 18.7 percent) but have large lower extremities (9.4 percent) and larger hearts (0.74 percent) than do the puffbirds, although they also remain in one spot for a long time.

Ramphastidae.—The restlessly active toucans are weak fliers (flight muscles, 20 to 23 percent; hearts, 0.62 to 0.81 percent), but they have large lower extremities (9 to 12 percent). Specimens of *Pteroglossus torquatus* found at sea level are smaller ($P<0.05$ for males, and $P<0.01$ for females) and have a smaller heart ($P<0.01$) than those of *Pteroglossus frantzii* obtained at 4,300 feet above sea level. Pectoralis plus supracoracoideus muscles show corresponding proportions in the two species.

Picidae.—The woodpecker, aptly called "carpintero" by Spanish-speaking natives, devotes much of his time to chiseling holes in tree trunks for food or nest. His legs (6 to 11 percent) and his heart (0.81 to 1.41 percent) are fairly large. Sizable flight muscles (22 to 29 percent) and large and broad wings (buoyancy index, 3.39 to 4.25; aspect ratio, 1.62 to 2.07) give him the power for his characteristic undulating flight marked by a series of graceful dips. The largest woodpeckers studied, of the genus *Phloeoceastes,* possessed the smallest wing and glide areas but the largest legs. The downy woodpecker flies rapidly, the pileated woodpecker, slowly but vigorously, at times, like a crow, otherwise in short swings and dips like other woodpeckers.

Dendrocolaptidae.—Woodhewers, like the woodpeckers, climb trees in search of food, frequently making short, strong flights to a new tree, where the quest is repeated. The hearts are large (1.10 to 1.48 percent) in the smaller species and of medium size (0.65 to 0.93 percent) in the others. The pectoralis plus supracoracoideus muscles are larger in the male than in the female in *Xiphorhynchus guttatus and Lepidocolaptes affinis* ($P<0.01$). The legs are similar in size to those of the woodpeckers. The buoyancy index is large (3.65 to 4.20).

Furnariidae.—In the ovenbirds there is a wide variety of habits, ranging from those of terrestrial species to those of species that climb trees, bracing with the tail. Flight is weak to strong (flight muscles, 16 to 30 percent), and the wings are large (buoyancy index, 3.0 to 4.0). As might be expected, the muscles of the lower extremities are large (8 to 13 percent). The heart muscles are moderate (mostly 1.0 to 1.16 percent) except in *Anabacerthia* (1.49 percent) and *Automolus* (1.48 percent).

Formicariidae.—Like the ovenbirds, antbirds may be arboreal or terrestrial. All have large muscles in the lower extremities (8 to 14 percent) but small to medium flight muscles (16 to 23 percent) except for *Formicarius* (30.5 percent). As in other birds that fly among close vegetation, their wings are large (buoyancy index, 3.15 to 3.75) and broad (aspect ratio, 1.45 to 1.59). Hearts range from 0.58 to 1.26 percent.

Pipridae.—Among the manakins, *Corapipo* and *Schiffornis* have a high heart value of 1.50 percent, compared to 1.06 percent for *Manacus* and 1.11 percent for *Pipra*. In view of the practice of dancing on the part of the male, larger leg muscles than in the female might be expected. In *Corapipo* we found no great difference, but in *Manacus* the leg muscles of the male were larger than those of the female (11.91 percent compared to 8.42 percent). Moreover, the leg muscles of *Manacus* were larger than those of other manakins. Lowe (1942) mentions that the pectoralis and thigh muscles of the male are very well developed.

Cotingidae.—The cotingas, birds of the forest, are peculiar to the warmer parts of the Americas. Arboreal in habit, they possess strong flight equipment for movement among the tree tops (22 to 33 percent flight muscles; buoyancy index, 3.28 to 4.83; aspect ratio, 1.65 to 2.00). The hearts are large (1.11 to 1.45 percent) and the legs moderately so (5.15 to 8.18 percent).

Tyrannidae.—The tyrant flycatchers constitute one of the largest families of American birds (365 species, according to Van Tyne and Berger). Those found south to Panamá are mostly arboreal, darting from a strategic perch to capture insects. There is great variation in their musculature, heart size ranging from 0.71 to 1.88 percent and flight muscles from 16 to 33 percent. Large and broad wings (buoyancy index, 3.39 to 4.71; aspect ratio, 1.46 to 2.05) give great maneuverability. The muscles of the lower extremities show considerable range (3 to 7.35 percent). Their adaptations for catching prey or for bold attacks in defense of territory are quite varied. The genus *Todirostrum* in proportion to its size has much larger muscles of the lower extremities and smaller flight muscles than do other members of the family.

Hirundinidae.—As swallows spend much time in the air, their legs are very small, being used only for perching (lower extremity muscles, 1.80 to 2.84 percent), yet their flight muscles are not unusually large (19.7 to 25 percent). All except *Progne* have very large, narrow wings (buoyancy index, 4+; aspect ratio, 2.3 to 2.6) and fairly large tails.

Corvidae.—The jay family contains the largest passerine birds and some of the most aggressive ones. Although fairly strong fliers (flight muscles, 20 to 25 percent; buoyancy index, 3.4 to 4.7), they use their feet extensively in walking and manipulating food (lower extremity muscles, 10 to 15 percent). Their hearts are of moderate size (0.85 to 1.0 percent).

Paridae.—Titmice display restless, acrobatic activity; they use their feet to hold prey. Their hearts are large (1.35 to 1.49 percent), the flight muscles (23 to 27 percent) and leg muscles (7 percent) fairly so. They are weak fliers, and the wings are typical of perchers.

Sittidae.—The nuthatches are similar to the titmice in muscular proportions but somewhat different in habits. They not only hop over the bark looking for food, but the red-breasted nuthatch also catches insects in the air like a flycatcher.

Certhiidae.—The creepers are good fliers, possessing large hearts (1.48 percent) and large wings (buoyancy index, 4.22) and tails (2.35 $cm.^2$ per g.)

Troglodytidae.—The members of the fairly large family of wrens are weak fliers and do much running around in exploring for food and in other activities; as might be expected, their leg muscles are large (10 to 13 percent). Hearts (0.86 to 1.19 percent), flight muscles (16 to 20 percent), and wings (buoyancy index, 3 to 3.39) are moderate in size.

Mimidae.—Mockingbirds and thrashers show values much like those of wrens but have smaller leg muscles (8.0 to 9.7 percent). Although partly arboreal, they also do much feeding on the ground.

Turdidae.—The above remarks concerning the Mimidae apply also to the thrushes, except that the latter possess large flight muscles (20 to 36 percent).

Sylviidae.—The smaller gnatcatchers may also be described in much the same way as the wrens, above.

Motacillidae.—Although the pipits are terrestrial in their habits, running about rapidly, their leg muscles are of only moderate size (6 percent). They are powerful and swift fliers, having fairly large flight muscles (28 percent), large, broad wings (buoyancy index, 3.66; aspect ratio, 1.77), and large hearts (1.57 percent).

Bombycillidae.—Waxwings have flight power similar to that of the pipits, but their wings are somewhat smaller (buoyancy index, 3.29) and narrower (aspect ratio, 2.13). Their hearts are large (1.54 percent).

Ptilogonatidae.—The silky flycatcher (*Ptilogonys caudatus*) has a large heart (1.33 percent) and a high buoyancy index (3.80).

Laniidae.—The loggerhead shrike (*Lanius ludovicianus*) makes brief, swift flights through the air to seize a victim, but his muscles are moderate in size.

Sturnidae.—The common starling (*Sturnus vulgaris*) is a very active bird with rather small, narrow wings (buoyancy index, 3.17;

aspect ratio, 2.19) and fairly large legs (7.76 percent). In short flights he appears slow and feeble, but on long journeys he flies strongly and swiftly.

Cyclarhidae.—Concerning peppershrikes it need only be noted that they have large leg muscles (9.46 percent) and that their flight is deliberate and weak.

Vireonidae.—Vireos, feeding mostly among the leaves, are moderately endowed with muscles: heart, 1.06 to 1.43 percent; flight muscles, 21 to 25 percent; leg muscles, 5.89 to 7.63 percent. They do, however, have large wings (buoyancy index, 3.44 to 3.88).

Coerebidae.—Honeycreepers, being quick in the air, have flight muscles ranging from 23 to 34 percent and large hearts (1.25 to 1.44 percent). Their wings are large (buoyancy index, 3.37), but their legs are only moderate in size (muscles, 5 to 8 percent).

Parulidae.—Although the wood warblers range from the treetops (black-throated green warbler) through lower levels of the forest (magnolia warbler) to the ground (Kentucky warbler), their flight muscles do not differ greatly, as their activities in the air are similar. These muscles are not large, ranging mostly from 20 to 25 percent of the body, with many around 22 percent. The wings (buoyancy index, 3.27 to 4.16) and tails are large, making the glide area as high as 10 $cm.^2$ per gram in some species. The muscles of the lower extremities are largest in *Basileuterus* (9 to 10 percent) and as low as 5 percent in others. The hearts range from 0.95 to 1.39 percent.

Ploceidae.—The house sparrow (*Passer domesticus*) is typical of many small perchers; large heart (1.39 percent) and flight muscles (25.4 percent); wings designed for quick takeoff (buoyancy index, 3.05; aspect ratio, 1.88); and moderate lower extremities (muscles, 6.47 percent).

Icteridae.—Icterids show characteristics similar to those given above: hearts, 0.85 percent in *Sturnella magna* to 1.2 percent in *Icterus galbula;* flight muscles, 19 percent in *Amblycercus* to 28 percent in *Leistes;* buoyancy index, 3.13 for *Sturnella* to 4.4 for *Cacicus;* aspect ratio, 1.31 for *Amblycercus* to 2.03 for *Psarocolius;* lower extremities, 7.46 percent for *Icterus spurius* to 15.2 percent for *Amblycercus.*

Thraupidae.—Thraupids show a greater range in heart size than the fringillids, *Rhodinocichla* possessing the smallest (0.63 percent), the male *Habia rubica* the largest (1.46 percent). Flight muscles also show a somewhat greater range: 1 percent in *Chlorospingus* and 29 percent in *Thraupis.* Buoyancy index likewise runs from 2.82 in

Tanagra to 3.98 in *Habia,* while the aspect ratio is only 1.47 in *Rhodinocichla* but reaches 1.89 in *Piranga rubra.* The muscles of the lower extremities are from 5.19 percent in *Tanagra luteicapilla* to 11.36 percent in *Rhodinocichla.*

Fringillidae.—This almost worldwide group of birds, feeding everywhere that seeds are to be found from the ground to the treetops, shows a great range of locomotor equipment. Their hearts vary from 0.60 percent in *Pezopetes* to 1.57 percent in the male *Saltator maximus,* and flight muscles show as great a range (19.5 to 29 percent). The buoyancy index of the wings ranges between 3.09 and 3.72, the aspect ratio between 1.42 to 1.88. The highest values for muscles of the lower extremities are more than twice as high (13.2 percent) as the lowest (5.43 percent).

After this survey of the variations in the families, let us compare the locomotor organs individually.

HEARTS

Since the heart limits the activities of a bird, it is proper to consider it first. Whatever the size of a musculature, it cannot act for long without an adequate circulation. Thus the tinamou, with its tremendous breast muscles but very small heart, can make only short flights. On the other hand, birds with only a moderate equipment of muscles can fly for long periods if they possess large hearts. It is this relationship between the heart and the locomotor muscles that we wish to deal with primarily, but there are other factors which also must be considered, namely, sex, season, latitude, and altitude.

Sex.—Whenever there is evidence of sex difference in the relative weight of the heart, the sexes are separated for consideration. In the following species the hearts are heavier in the male than in the female: *Gallus gallus, Phaethornis guy, Anthracothorax nigricollis, Chlorostilbon canivetii, Damophila julie, Amazilia edward, Amazilia tzacatl, Elvira chionura, Lampornis castaneoventris, Selasphorus scintilla, Sittasomus griseicapillus, Cranioleuca erythrops, Anabacerthia striaticollis, Mitrephanes phaeocercus, Thryothorus modestus, Habia rubica, Habia fuscicauda, Saltator maximus,* and *Pipilo erythrophthalmus.* Heavier hearts in males may also hold for other species, but the number of individuals available is not always sufficient to settle the question.

Seasonal variation.—A difference in relative heart size is noted in certain Florida birds collected in June as compared with those obtained in the winter months, as shown in table 2 (p. 88).

Latitude.—A difference in heart size is noted in a few species collected in Florida compared with the same or closely related species obtained in Panamá, the hearts of Florida birds being larger. These species are *Butorides virescens, Coragyps atratus, Cathartes aura,* and *Sturnella magna.*

Altitude.—Larger hearts are present in some species at higher altitudes when compared with other species of the same family at lower altitudes. Specimens of *Crotophaga ani* and *Piaya cayana* obtained at 4,500 feet have larger hearts than those of the same species obtained at sea level ($P<0.01$).

In general the smaller birds have relatively larger hearts than large birds. The lowest values appear for the tinamids, followed by the strigids, nyctibiids, momotids, and bucconids, with others of lesser deviations from the mean. The highest values emerge for the trochilids, hirundinids, motacillids, and bombycillids. Comparison of the heart weight with the habits of the bird leads one to the conclusion that heart weight is directly related to the ability to sustain power flight.

The muscles of locomotion show even greater variation. I shall consider first the muscles used in flight. As already indicated, we weighed all the muscles involved except the small muscles along the carpals, metacarpals, and phalanges.

FLIGHT MUSCLES

Sex, latitude, and altitude appear to have some influence in muscle size in a few species.

Sex.—In *Cairina moschata* (domestic) the female possesses flight muscles that are larger than those of the male, while in *Micrastur ruficollis, Phaethornis guy, Amazilia amabilis,* and *Manacus vitellinus* flight muscles are larger in the male. In other species our data are insufficient to determine the sex differences in the more inclusive flight muscles, but in the more limited combination of pectoralis plus supracoracoideus, where we have more data, these muscles are larger in the male than in the female of *Pelecanus occidentalis, Micrastur ruficollis, Amazilia amabilis, Amazilia edward, Amazilia tzacatl, Lampornis castaneoventris, Selasphorus scintilla, Pharomachrus mocinno, Sittasomus griseicapillus, Xiphorhynchus guttatus, Lepidocolaptes affinis, Anabacerthia striaticollis, Myiarchus tuberculifer, Empidonax flavescens, Mitrephanes phaeocercus, Thryothorus modestus, Tangara ic-*

terocephala, Thraupis espicopus, Piranga leucoptera, Habia fuscicauda, and *Saltator maximus.* In only two species, *Jacana spinosa* and *Vireo philadelphicus,* were the pectoralis plus supracoracoideus larger in the female than in the male.

Latitude.—The pectoralis plus supracoracoideus muscles were relatively heavier in Panamá specimens of *Florida caerulea* and *Cathartes aura* than in birds of the same species collected in Florida.

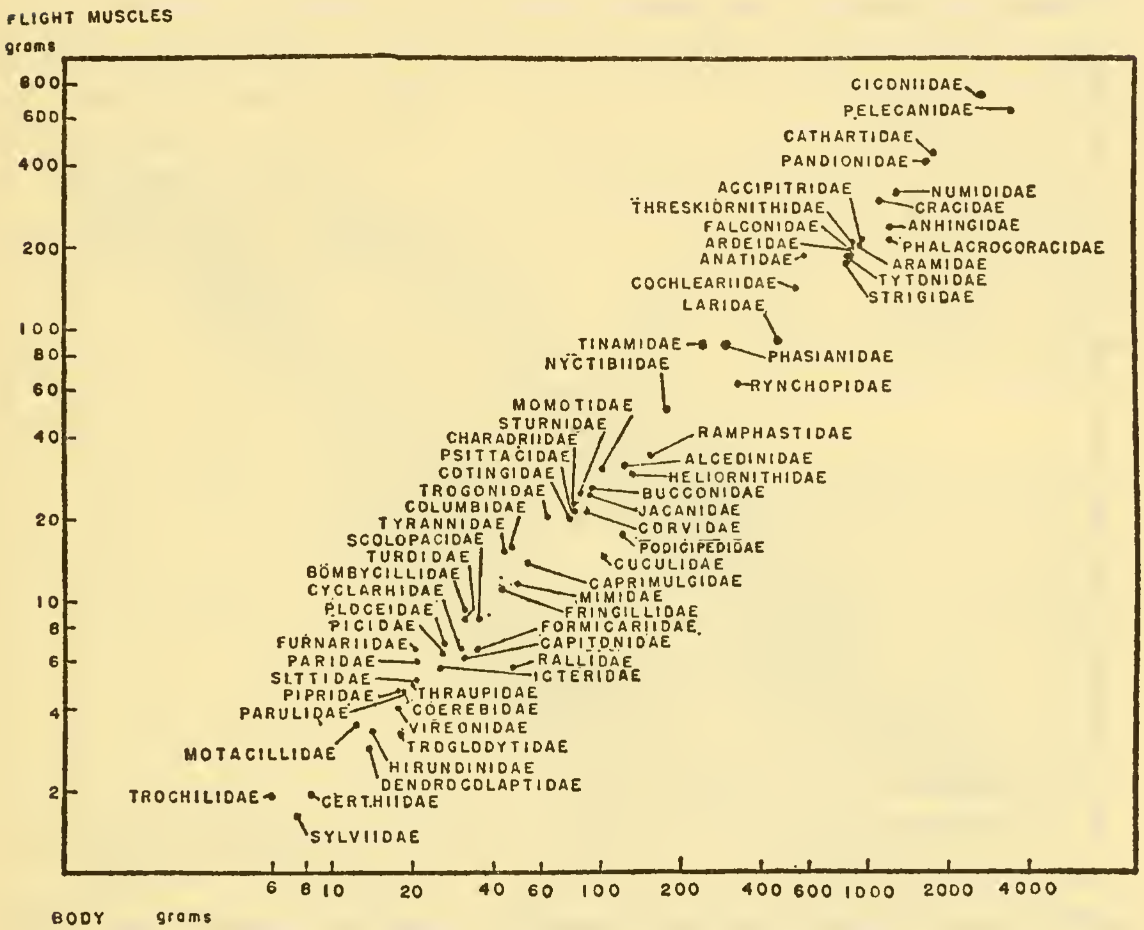

FIG. 1.—Selected plottings (see asterisks in table 1) of upper extremity muscle weights against body weights (log scales).

Altitude.—In *Piaya cayana* and *Crotophaga ani* both flight muscles and pectoralis plus supracoracoideus were relatively heavier in high-altitude birds (4,300 ft.) than in these species collected on the Río Chagres. Likewise the pectoralis plus the supracoracoideus were heavier in *Pteroglossus frantzii* (collected at 4,300 ft.) than in *Pteroglossus torquatus* obtained on the Río Chagres.

For an overall comparison of the flight muscles, selected species from each family have been plotted on a logarithmic scale (fig. 1). If one draws a line through the values for the heavier birds, it will be seen that many of the birds less than 200 grams in weight are decidedly above this line, only the Rallidae, Cuculidae, and Podicipedidae falling below.

Since the pectoralis (pectoralis superficialis or p. major) is the most important muscle in depressing the wing, it was also treated separately (fig. 2). It will be seen that the divergences from a straight line are

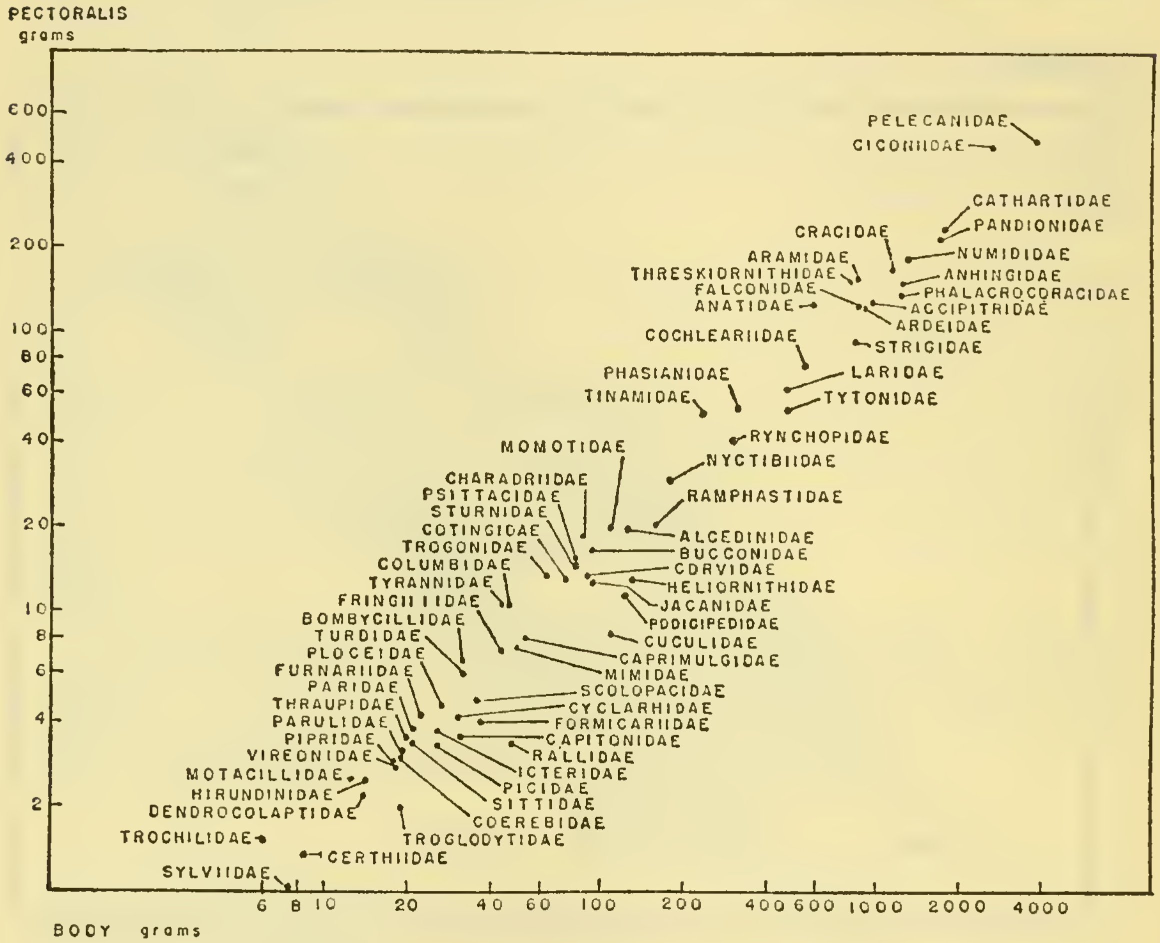

FIG. 2.—Selected plottings of pectoralis superficialis muscle weights against body weights (log scales).

not only different, but sometimes greater than those observed for the flight muscles as a whole. Those with a large pectoralis also have large flight muscles, and vice versa. Examples of those with a relatively large pectoralis are found in the tinamids, threskiornithids, anatids, phasianids, charadriids, columbids, psittacids, trochilids, trogonids, cotingids, motacillids, coerebids, and thraupids. Those with a relatively small pectoralis are the podicipedids, phalacrocoracids, some ardeids, some accipitrids, rallids, heliornithids, cuculids, formicariids, and troglodytids.

Although there is a tendency toward similarity among different species in the same family, it will be recalled that there are some exceptions. In the herons the range of the pectoralis is from 10 to 17 percent of the body weight; in the flycatchers, from 12 to 22 percent; in the swallows, from 14 to 21 percent.

Supracoracoideus.—The supracoracoideus, one of the principal levators of the wing, appears to be of little importance in many birds, judging from its size. In our studies it ranged from about 0.40 percent of the body in species of the genus *Buteo* to 11.5 percent of the body in the trochilids, or 1.8 to 30 percent respectively of the flight muscles. High values (table 1) are found in *Crypturellus, Chamaepetes, Odontophorus, Numida, Capella,* trochilids, doves, *Pyrrhura,* and *Manacus.* Low values appear in *Phalacrocorax, Buteo, Pandion, Caracara, Piaya, Tyto,* and *Pulsatrix.* The supracoracoideus of *Nyctibius* (3.18 percent of the flight muscles) is much smaller than that of *Nyctidromus* (6.9 percent of the flight muscles). There is a great difference in this muscle in *Manacus* (14.2 percent of flight muscles) as compared to that in *Chiroxiphia* (6.0 percent of flight muscles). Likewise, this muscle is larger in *Cotinga ridgwayi* (7.76 percent of flight muscles) than in *Querula* (4.56 percent of flight muscles).

The range of supracoracoideus among different families is shown in figure 3. It will be noted that the greatest differences are to be found in the larger birds, the muscle being largest in those birds that make a quick takeoff. It is especially small in cuculids, tytonids, and strigids.

"Rest."—The combined muscles of the shoulder, brachium, and forearm (except those noted above), which appear in the table under the heading "Rest," are shown in figure 4. With fewer exceptions than in the other muscle groups, they tend to follow a straight line. Among the lowest are the grebes, rallids, certhiids, and sylviids.

Division of this group of muscles into shoulder, brachium, and forearm shows variations among the different families and among some species of the same family. This has been done for 67 species distributed among 32 families. Typical examples have been chosen in table 3 (p. 89). The shoulder group shows low values in *Anhinga* (1.04 percent), *Ardea* (1.47 percent), *Polyborus* (1.60 percent), *Ereunetes mauri* (1.13 percent), *Thalasseus* (1.37 percent), *Columba livia* (1.26 percent), and *Crotophaga* (1.60 percent). It was high in *Tinamus* (3.44 percent), *Heterocnus* (3.07 percent), *Chondrohierax* (3.30 percent), *Ortalis* (3.34 percent), *Colinus* (3.42 percent), *Columba speciosa* (3.15 percent), *Megaceryle* (3.25 percent), and *Mniotilta* (4.46 percent). These muscles were larger in *Colinus* (3.42 percent) than in *Odontophorus* (2.05 percent) and *Gallus* (1.61 percent).

The muscles of the brachium are usually heavier than those of the forearm, especially in the anatids, *Coragyps, Megaceryle,* picids, *Synallaxis, Muscivora, Iridoprocne,* corvids, parulids, icterids, and fringillids.

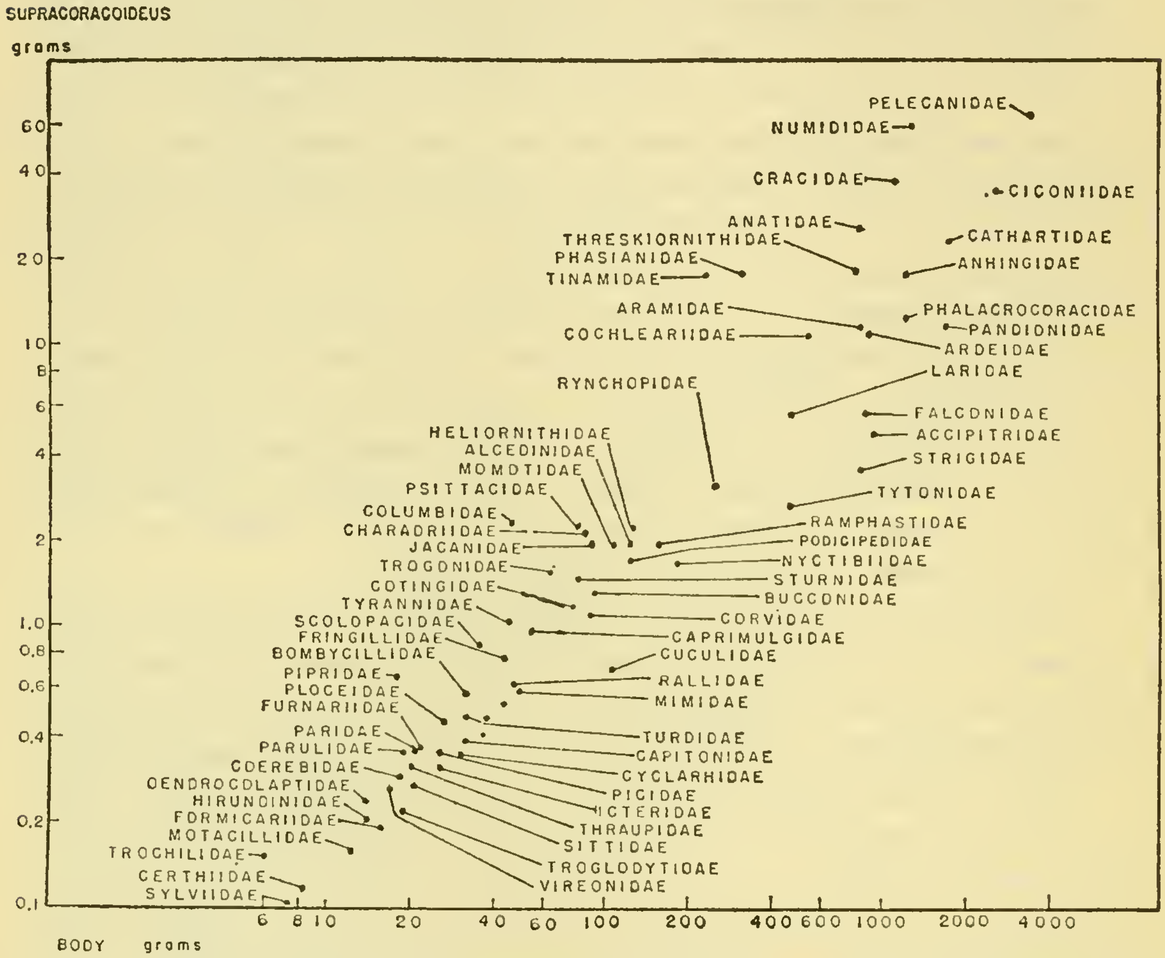

FIG. 3.—Selected plottings of supracoracoideus muscle weights against body weights (log scales).

LOWER-EXTREMITY MUSCLES

Muscles of the lower extremities vary much in size because of the great difference in degree of activity. In some birds they are used little, even for perching, while in others they may be the essential means of locomotion or may serve as important tools in obtaining food. Examples of typical species in the various families are shown in figure 5. The smallest muscles (1.2 to 3 percent) are found in trochilids, nyctibiids, alcedinids, and hirundinids; the largest are found in the tinamids, podicipedids, cathartids, cracids, phasianids, and rallids (14 to 23 percent). They are larger in the male than in the female in *Cairina* and *Gallus* (table 1).

Separation of the lower extremity into thigh and leg was done in the same specimens in which the muscles of the upper extremity were separated. The variation of the proportion of thigh to leg muscles is usually not great (table 4, p. 90). In many birds the thigh muscles are

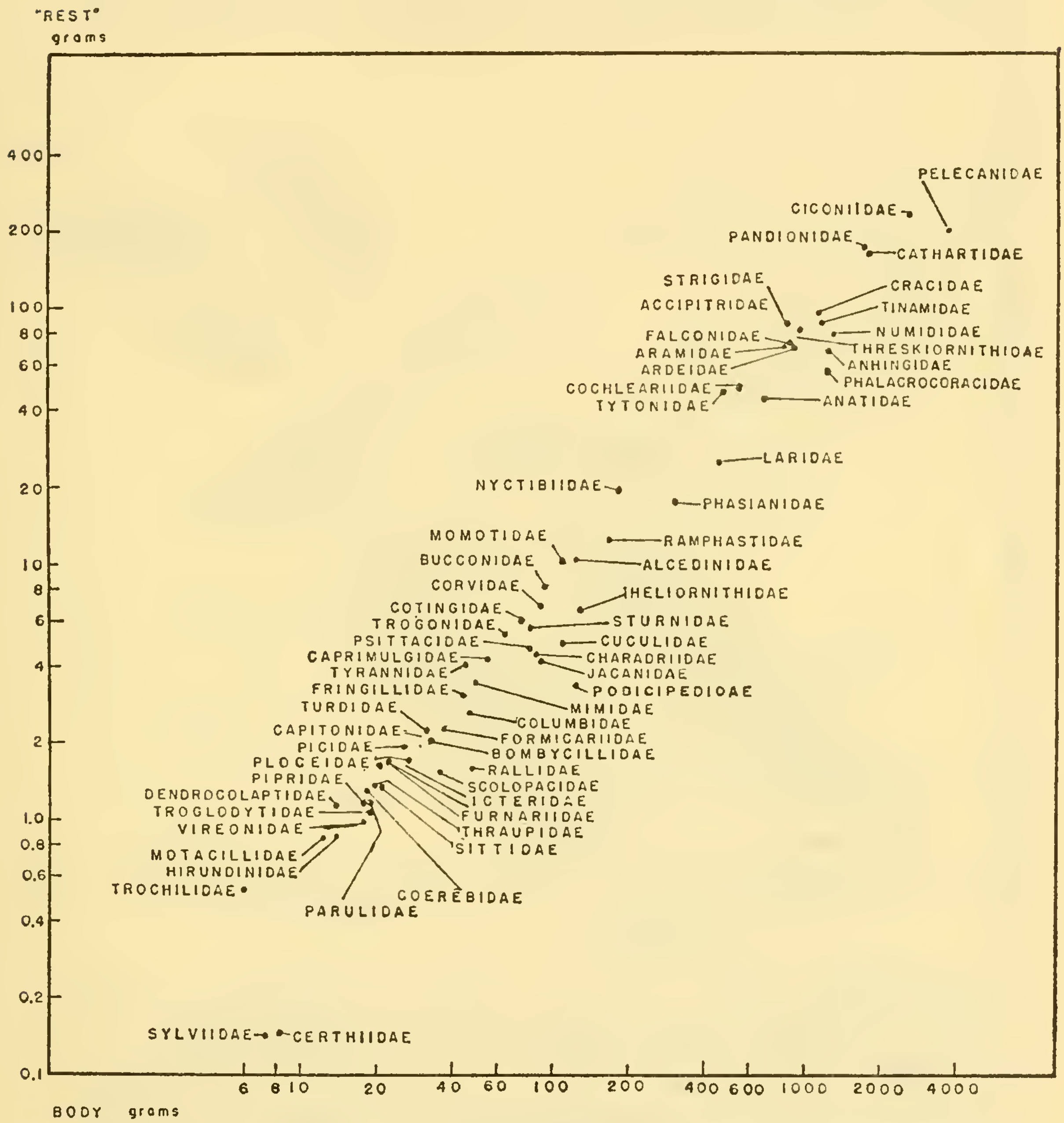

FIG. 4.—Selected plottings of "rest" muscle weights against body weights (log scales).

nearly equal to those in the lower leg; when they are unequal, it is usually the thigh that is larger. Exceptions are *Phalacrocorax,* some ardeids, and *Buteo lineatus,* in which the thigh muscles are smaller. Comparison of a domesticated phasianid, *Gallus,* with a wild species, *Odontophorus,* is interesting. The lower extremity muscles that are still used by the domestic form are the same size as in the wild form, but the pectoralis and supracoracoideus muscles are less than half the size of those of the wild form, as is also the wing area.

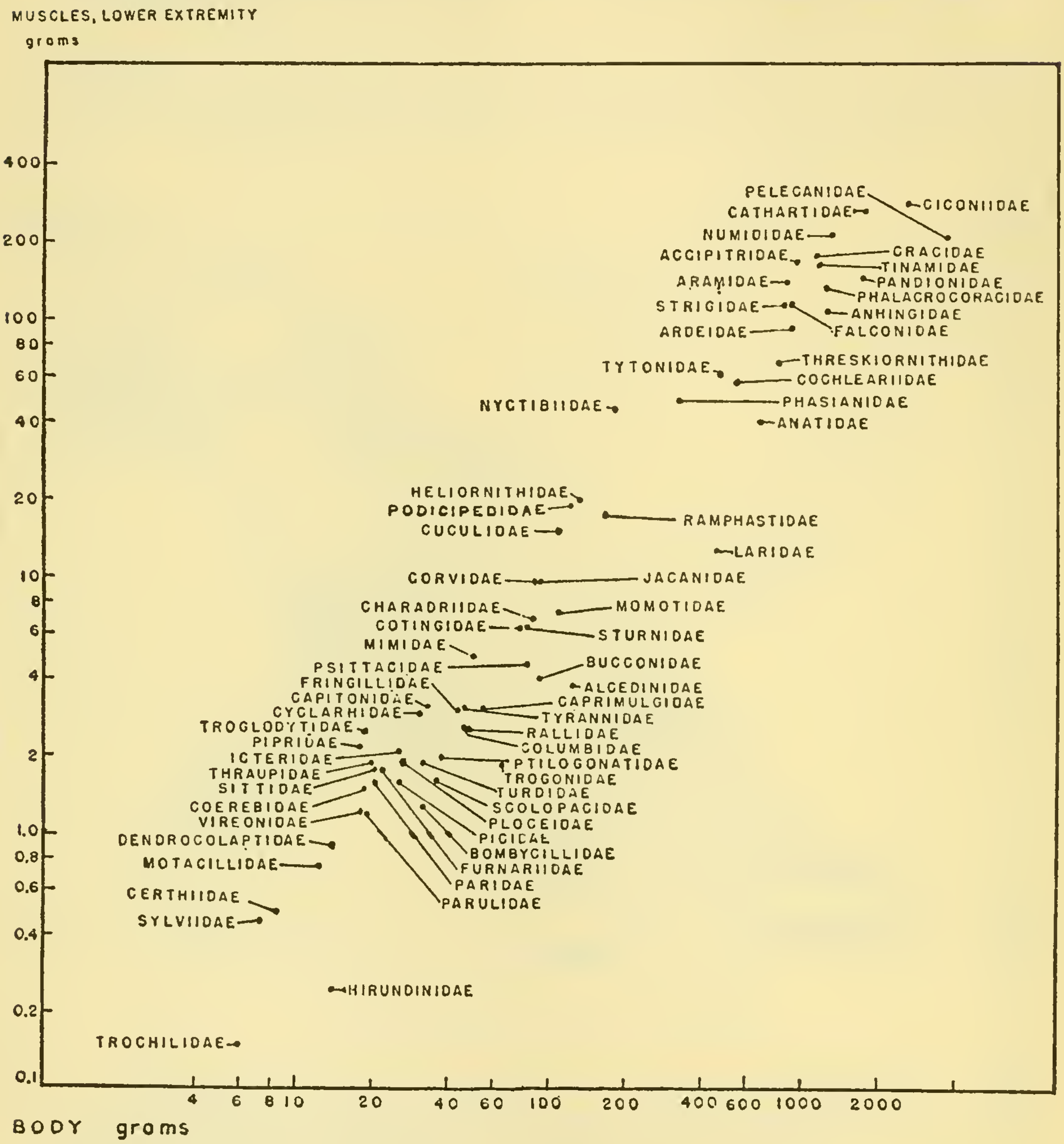

FIG. 5.—Selected plottings of lower-extremity muscle weights against body weights (log scales).

BODY AREAS INVOLVED IN FLIGHT

The surface areas involved in flight are the wings used in propulsion, the tail and wings for steering, and the tail and body for gliding or soaring. The wing and glide areas for typical examples of each family are shown in figure 6.

WINGS

In general, the smaller birds show less divergence and have larger wings than the heavier birds. Exceptionally small wing areas are present in rallids, podicipedids, tinamids, anatids, cracids, scolopacids, and phalacrocoracids. Large wing areas are found in several small

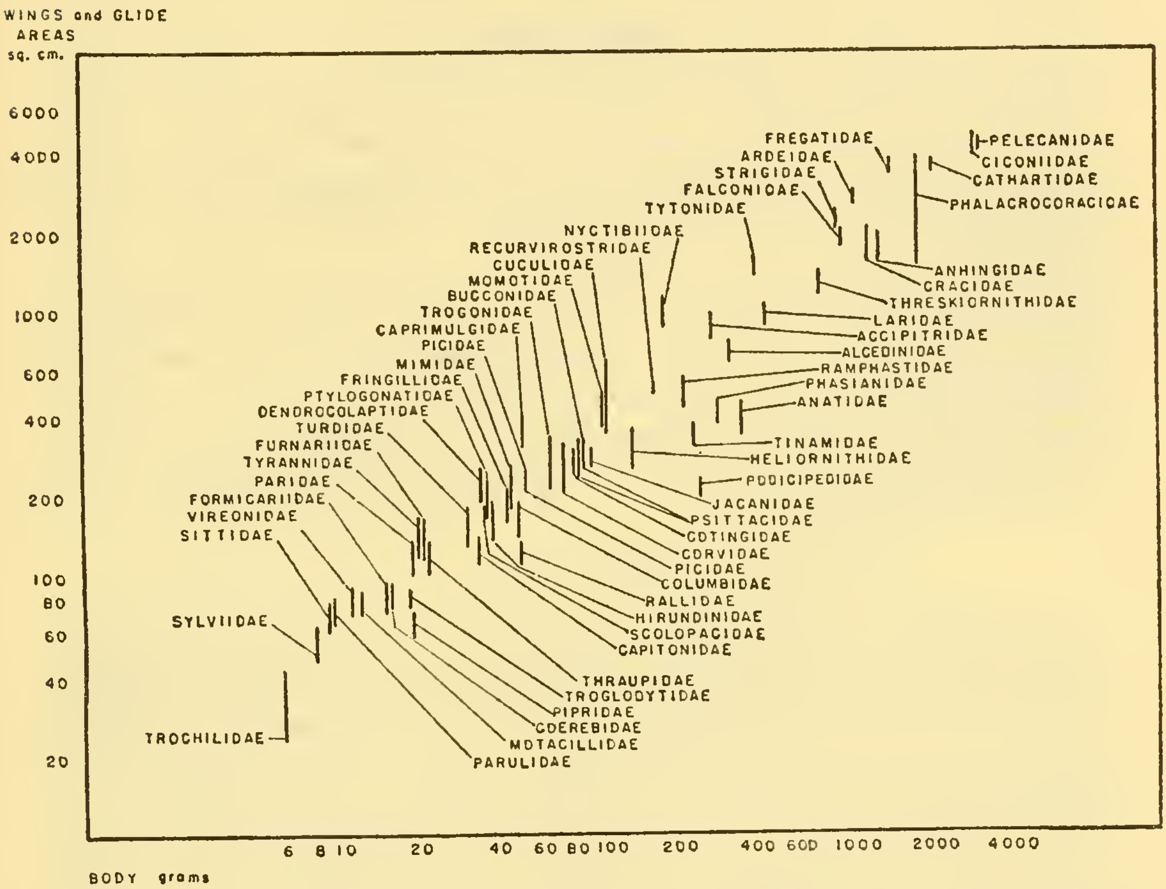

FIG. 6.—Selected plottings of areas for wings (low end of vertical lines) and glide (high end of vertical lines) against body weights (log scales).

tyrannids, especially *Mitrephanes;* in other families in *Sittasomus, Xenops,* and *Myrmotherula,* hirundinids, *Sitta,* and several parulids.

Sex.—The wings of the males in the following species are significantly larger than those of the females: *Buteo lineatus* ($P<0.05$), *Tanagra icterocephala* ($P<0.01$), *Tanagra guttata* ($P<0.01$), *Tanagra gyrola* ($P<0.05$), *Saltator maximus* ($P<0.01$), and *Pipilo erythrophthalmus alleni* ($P<0.01$). In *Cassidix mexicanus* the wings are larger in the female than in the male ($P<0.05$).

Altitude.—*Momotus momota* collected at sea level has larger wings than the same species collected at 4,500 feet above sea level ($P<0.01$). Among the piprids, *Corapipo* collected at 4,500 feet elevation has wing and glide areas nearly twice those of *Manacus* collected at sea level, but this may not be an altitude effect.

Ratio of buoyancy index.—Values for the buoyancy index are shown in table 1. *Cathartes* tops the list with 5.86. *Nyctibius* and *Casmerodius* tie for second place, and *Pandion* is third, *Tyto* fourth, *Coragyps* fifth, and *Cochlearius* sixth. The lowest is *Manacus* (2.79).

ASPECT RATIO

The ratio of the length to the width of the wing, or aspect ratio, indicates the adaptation for soaring or quick takeoff—the long, narrow wing (high ratio) for soaring, and short, broad wing (low ratio) for prompt takeoff. Most small birds possess a low ratio, the cuckoo being the lowest. Exceptions are goatsuckers, trogons, potoo, shore birds, swallows, and hummingbirds, which are high, the last three being the highest. Of the heavier birds. *Chaemepetes* is the lowest, while the gull, frigate-bird, and pelican are the highest of all birds studied. The barn owl has a longer wing than the other owls that we have studied. *Corvus* has a much larger aspect ratio than the other corvids observed.

TAIL AREAS

The relative size of the tails is shown in figure 7. The tails in grebes were so small that they were not measured. They are small in shrikes, rails, jaçanas, and tinamous, and large in *Fregata, Anhinga,* falconids, cracids, cuculids, some strigids, the nyctibiids, caprimulgids, trogons, dendrocolaptids, furnariids, tyrannids, corvids, parids, mimids, turdids, sylviids, *Ptilogonys,* and fringillids. Hummingbird tails are relatively the largest of all. The tail of the turkey vulture is larger than that of the black vulture.

The size of a tail does not necessarily indicate its effectiveness, since it may be an ornament as in the male quetzal. However, in most instances it can be a factor in steering, gliding, or soaring.

GLIDE AREAS

The combined areas of wings, tail, and body make what we have called the glide area. An examination of table 1 will show that these areas tend to parallel the wing areas (see fig. 6). This is to be expected, since the wings constitute a large proportion of the total, the tail being relatively small in most instances. In those birds in which glide areas are much larger than the wing areas, the large tails usually account for the increase, as in trogons and cuckoos. In a few birds the wings are largely responsible for the glide area. This is true for wrens, tinamids, the stilt, grebes, herons, and some others.

DISCUSSION

All values in this study are based on body weights, which, of course, vary with the state of nutrition, hydration, and food content. By using only healthy, well-nourished birds and collecting them during the

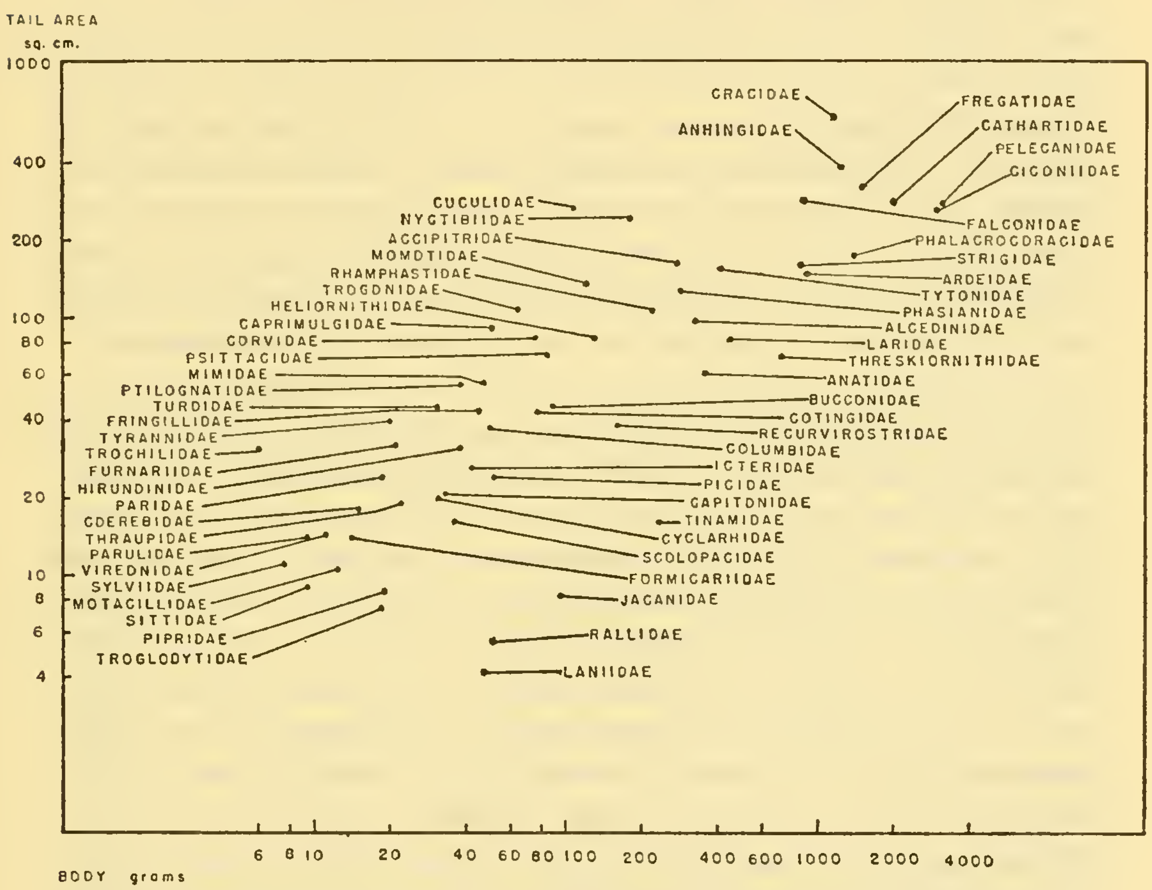

FIG. 7.—Selected plottings of tail areas against body weights (log scales).

morning hours, the conditions are standardized as well as could be expected. In a few species that have large capacity and gorge themselves periodically, food contents should be considered. By having a sufficient number of individuals in a species, these variables are reduced. When values are far from the mean, as occurs occasionally, they have not been included.

Our observations show that muscle weights are related to activity. Muscles represent potential power but do not indicate the extent of their use. A large muscle may produce powerful contractions, either brief or sustained depending upon the heart that supports it. A small muscle, while not powerful, can continue contraction for a considerable period if supplied with oxygen and fuel. The flight muscles tend to parallel the performance in the air, while the muscles of the lower extremities are related to their use for locomotion or for acquiring food. Most important of the muscles is the heart, since it is the driving force that circulates oxygen and nutrients and removes waste products. A small heart limits activity, while a large one can maintain it much longer.

We had previously found no difference between the sexes in the relative heart weight (Hartman, 1955), but in the present survey we observed that in 19 species the heart in the male was relatively heavier than in the female; if more data were available the list might be increased. This difference occurred in small or relatively small birds, with the single exception of *Gallus.* In some species the males are more active than the females, but we cannot say whether this was so in the 19 species in which a difference was observed. Groebbels (1932) noted a difference in heart size between the sexes in some species.

In my earlier paper (Hartman, 1955) evidence suggesting a seasonal difference in heart weight was presented, but the number of individuals was too small to make the findings significant. This shortcoming was obviated in the present work in the case of a few species by the inclusion of a sufficient number of individuals. Birds collected in January and February possessed hearts larger than those obtained during June, a finding contrary to the suggestive evidence in the former paper. Such a difference could be explained by the higher rate of metabolism in the cooler weather. In keeping with this interpretation we find that certain species living in Florida possess larger hearts than the same species from Panamá. Since many *Cathartes aura* migrate to the south in winter, the season when our Panamá birds were collected, the question has been raised as to the identity of some of these birds. Whether they were migrants or not, there were very significant differences in the hearts and pectoralis plus supracoracoideus muscles between the two groups.

If altitude is a factor in increasing the heart size, why do not more species show the effect? Some of those that have larger hearts at the higher altitude are not very active (e.g., cuckoos). Perhaps additional data would extend the difference to more species. Stieve (1934) compared heart size in *Lagopus mutus mutus* and *L. lagopus lagopus,* both from the same altitude (400 to 700 m.). The alpine grouse (*L. m. mutus*) at this low level has a distinctly larger heart than the moor grouse. Therefore in these instances it is a species difference rather than an altitude effect. Stieve also compared hearts of *Lyrurus lyrurus tetrix* from different altitudes. Birds from higher levels (1,800 to 2,000 m.) possessed definitely smaller hearts than those living at 50 meters. The same could be shown in other species. Several authors (e.g., Parrot, 1893, and Rensch, 1948) have concluded that birds flying great distances or living in northern latitudes or high altitudes possess larger hearts than those less active or living in warmer climates.

A thorough study of the muscles used in locomotion should include the weight of each individual muscle because of the variation from species to species. Since this is impossible in an extensive survey, only the larger muscle groups have been weighed. The pectoralis superficialis is the most important in flight, as it depresses the wing, while the supracoracoideus is the principal levator of the wing. The remainder of the flight muscles (called "rest" in our study) also play an important role in the flight, whether it be in maneuvering or "setting" the wing for the action of the "power" muscles.

The flight muscles constitute a considerable proportion of many birds, varying from 14 to 40 percent. The percentage is lowest in those birds that use them least, but on the other hand, large size does not always indicate extensive use. The tinamou has very large flight muscles but makes only short flights. The flight muscles of the hummingbird, which spends much time in the air, are also relatively large, but not to be compared with those of the tinamou. The muscles of *Colinus, Chaemepetes,* and some trogons are relatively just as large as those of the hummingbird but are used much less.

The pectoralis superficialis, much the largest of the flight muscles, has received the most attention, but some authors have exaggerated its size. Stillson (1954) says, "In good fliers the pectoral muscles account for a large part of the total bird." Although Shufeldt (1890) said that in all the birds possessed of the power of flight, the pectoral muscles are second to none in importance, this is not true for grebes and some of the rails. In the former the leg muscles range from 15 to 18 percent, whereas the whole flight musculature is 14 percent or less. In *Aramides* the leg muscles are 24 percent, while the flight muscles are less than 17 percent.

Calculated from Fisher's (1946) data, the combined volume of all muscles that may aid in depressing the wing constitute 62.7 percent of the wing musculature in *Cathartes* and 56.2 percent in *Coragyps.*

Of these the pectoralis superficialis is 60.5 percent of the total in *Cathartes* and 54.1 percent in *Coragyps.* The volume of all muscles that may aid in raising the humerus is 15.9 percent of wing musculature in *Coragyps* and 12.3 percent in *Cathartes,* while the supracoracoideus is only 6.50 percent of all wing muscles in *Coragyps* and 4.40 percent in *Cathartes.* In our studies we did not determine the weight of all muscles used in raising the humerus, singling out the supracoracoideus because it was the most important and was easily dissected.

It has been reported by Owen (see Shufeldt, 1890, p. 73) that the supracoracoideus is almost the largest of the breast muscles in penguins, guillemots, and gulls. It was pointed out that more effort was required to raise the wings in the water than in the air. Divers such as the grebe (*Podiceps dominicus*) that use their feet for propulsion under water possess a small supracoracoideus. According to experiments of Convreur and Chapeaux (1926), all birds that fly require the muscles that raise the wings. After these muscles were severed in pigeons, it was not possible for the birds to launch themselves into the air or, when released from a height, to attain any semblance of sustained flight.

As was to be expected, the largest pectoralis was found in powerful fliers, either those accustomed to long sustained flight or those that fly for short distances at high speed. The pectoralis does its heaviest work when taking off.

Many more examples have been observed of heart differences in relation to altitude than of flight muscle differences. The heart must work almost continuously, being inactive only during diastolic pause, while the flight muscles work intermittently. Why the altitude difference occurs in cuckoos and not in more active fliers is difficult to understand.

While the supracoracoideus appears to be of little importance in many birds, it is largest in those birds that make quick takeoffs and fly rapidly, such as tinamous, quail, hummingbirds, and doves.

The remainder of the flight muscles, those of the shoulder, brachium, and forearm, constitute only a small part of the total, and therefore variation in these muscles, which is not great, may not be very significant as a factor in flight. The muscles of the brachium are usually heavier than those of the forearm, which would seem to indicate that they do more work.

Although the size of the muscle may determine the work that can be accomplished, the continuance of the performance depends upon the contained fat or other fuel, together with that which may be brought to it by the blood. The amount of fat in the pectoralis superficialis is lower in nonflying or poor-flying birds than in long-distance fliers such as the parakeet, pigeon, and crow, while the percentage of carbohydrate is higher in short-distance fliers such as the sparrow (Nair, 1952). The distribution of this fat has been shown by George and Jyoti (1955), who observed that in birds such as the pigeon, *Columba livia,* the pectoralis superficialis contained two types of fibers, a narrow type in which the sarcoplasm was interspersed with fat globules as well as opaque granules appearing to be liproprotein, and another broader, clearer type in which these inclusions were fewer. When the pigeons became exhausted from flying, the narrow fibers lost their fat globules. In the kite (*Milvus migrans*) the pectoralis superficialis contained fewer narrow fibers and less fat. The leg muscles of both species consisted only of the broad fibers with less fat. The leg of the fowl, however, contained a high percentage of fat. Continuous excitation of pectorals or leg muscles reduced their content of free lipid (George and Jyoti, 1957). These authors concluded that the muscle lipid supported prolonged activity.

The muscles supply the power for flight, while the wing and other areas are the foils with which the muscles operate. These surfaces are difficult to measure accurately because their artificial expansion may not duplicate exactly their natural expansion. Our values represent an approximation of the maximal expansion and, to that degree, the possible area available, but this does not tell us how these areas are used or how the areas are distributed in actual performance. In action there is frequent change in areas as well as in shape. Aspect ratio tells us a little but fails to give the shape, camber, or potential slots of the wing. The shape, stiffness, and character of the tail are also needed to complete the picture. These are all factors in flight and maneuverability. The combined action of the flight muscles and feather "blades" and "planes" determine the performance.

This combined mechanism is used either in flapless flight in which gravity is the factor, as in gliding, or in flapping flight in which muscular contraction overcomes the pull of gravity. In gliding, the bird may take advantage of winds or thermal currents, or it may dive.

The size of glide areas is not always an indication of the amount of gliding or soaring done by particular species. For example, *Mycteria* with a glide area of 1.76 $cm.^2$ per gram is a good soarer, while *Phaethornis* with a glide area of 7.14 $cm.^2$ per gram does not glide. Compare also the glide area of *Parus* (9.42 $cm.^2$ per g.) with that of *Stelgidopteryx* (9.55 $cm.^2$ per g.), two birds whose activities are very different.

Flapping flight may be in the form of "sculling" as in the gull, hovering as in the hummingbird, or rocketing as in the pheasant (Jack, 1953).

Although we have employed the ratio, wing area per gram of body weight, for comparisons, the wing loading $\left(\frac{\text{body weight}}{\text{wing area}}\right)$ could be used, as was done by Jack (1953). Perhaps buoyancy index is to be preferred.

It is interesting that when a sex difference is shown in wing areas, as in the case of sex differences in heart and flight muscles, it is the male that shows the larger values, except in *Cassidix mexicanus,* in which the reverse is true.

In some manakins, as well as in the motmot, larger wing areas occur in specimens collected at high altitudes than in those collected at sea level. Traylor (1950) reported that some species from a high altitude possessed longer wings than those from lower elevations.

We have reported 39 of the species discussed by Poole (1938), many of whose values are from single specimens. Seven of his species possessed a smaller wing area per gram of body weight than ours. In the following comparisons, his values are given first and ours second: *Dendroica pensylvanica,* 5.45–7.0 $cm.^2$ per gram; *Centurus carolinus,* 3.00–3.79; *Cyanocitta cristata,* 2.65–3.39; *Falco sparverius,* 2.74–3.50; *Sturnella magna,* 1.83–2.16; *Buteo lineatus,* 2.11–2.90; and *Cathartes aura,* 1.81–2.98. In all these species his specimens had larger body values than ours. In addition, three species with about the same body values had smaller wing values. They are *Dendroica virens,* 6.35–7.30; *Mniotilta varia,* 6.13–6.85; and *Stelgidopteryx ruficollis,* 6.79–7.54. Finally, his specimens of three species with smaller body values than ours possessed larger wing areas. They are: *Fulica americana,* 1.37–1.00; *Strix varia,* 3.59–2.49; and *Ardea herodias,* 2.33–2.06. These differences might be due to individual variation or to seasonal changes.

The tail is so variable in size, shape, and character that it may or may not be generally a factor in aerial locomotion. In many instances it has been observed to be useful in maneuvering. However, if the tail is small, the wings take over its function, as in the swift or duck. In the latter, on the other hand, because of the small wings together with the speed, the course of flight cannot be changed quickly.

The speed at which a bird flies is determined by the shape, size, and rate of beat of the wing and the angle of attack. Of course, the speed at which a bird can fly when pressed is not necessarily the speed that is customary. The greater the wing loading, the faster the bird must fly to prevent stalling. A long, narrow, pointed, flat wing is faster than a broad, curved one of the same area. Camber is greatest in slow fliers. Short wings are for bursts of speed. Wing areas are larger than absolutely necessary, especially in small birds, as can be shown in partial molts of wing feathers.

For sustained fast flying a low buoyancy index is best, while for soaring and gliding a higher index is an advantage (George and Nair 1952). *Coturnix* migrates considerable distances. Its aspect ratio is 2.15, its buoyancy index, 2.38, compared with a nonmigratory phasianid, *Colinus,* whose aspect ratio is 1.74 and buoyancy index 2.6.

Some birds are so equipped and so skilled that they have great control. The sparrow hawk, the kingfisher, and the hummingbird can hover, and the last mentioned can fly in any direction. The outer wing serves as propeller, while the inner wing, like that of a plane, gives "lift." In the hummingbird the wing is mostly propeller, giving great maneuverability but less efficiency. While this is satisfactory for a small bird, in a larger one greater efficiency is needed because weight increases by three dimensions while lift increases by only two dimensions (Storer, 1948).

In general, as has been stated by others, the small birds have relatively large, broad wings which give great maneuverability. This wing size is usually accompanied by tails that assist materially in quick change of direction or in landing. Small birds take off essentially by the same process as that used in free flight, the functions of lift and propulsion being common to a wing undifferentiated on the long axis and unadapted for kite-surface action (Demoll, 1930).

If the various species were arranged according to the size of the most important flight muscles (pectoralis superficialis plus supracoracoideus) we find that other values bear no relation to this arrangement. In table 5 (p. 91) typical examples are shown. Those species with 30 percent pectoralis plus supracoracoideus possessed wings ranging from 3.67 to 0.95 $cm.^2$ per gram (buoyancy index, 3.31 to 2.91), glide areas from 6.71 to 1.16 $cm.^2$ per gram, and hearts from 2.10 to 0.20 percent of the body. What does this indicate? The small wing would require a more rapid beat for the same performance. Large leg muscles suggest greater activity on the ground. The behavior of the birds listed bears this out. The hummingbird is a powerful sustained flier with little use for his legs. The tinamou is a ground bird and an explosive flier that spends little time in the air.

Consider the three birds with the smallest pectoralis plus supra-coracoideus in the table. None are especially good fliers. *Podiceps* has large legs which it uses in swimming. *Aramides* has the largest legs of all, which it can use in stalking through the swamps. *Crotophaga* spends much time on foot. Among the other birds in this table, the trogons, swallows, and kingfishers use their legs very little.

Let us examine the master table (table 1) with both the muscle size and flight areas in mind to see whether these values are related to the habits and activities of the bird. There appears to be a correlation; some illustrations may serve as examples. In the stork, *Mycteria,* the large legs indicate much ground work, yet the pectorals suggest medium flying power, the heart suggests ability to sustain activity, while the moderate wing area together with a high aspect ratio mean efficient flying and gliding once the bird is airborne. In the duck, *Aythya,* a medium-sized leg indicates moderate use, the pectoralis is fairly powerful, but the wings are small, thereby requiring a faster beat. An interesting comparison may be made in the two vultures. *Cathartes* has a much larger wing area and a greater aspect ratio than *Coragyps,* indicating more soaring and gliding, while the heart of *Cathartes* is small so that less sustained effort is possible. This agrees with the performance. *Coragyps* soars much less and flaps frequently in flight.

In the hawks large legs are useful in capturing prey, while large wings and high aspect ratio go with easy flight and soaring, but a medium-sized heart prevents long sustained effort.

All the rails have large legs but vary much in wing area. Their hearts can support moderate activity. The jaçana could be more active than the rails, having a larger heart, larger pectoralis, and very large wings, but medium-sized legs. Therefore, it could be in the air longer and fly with slower strokes. Likewise, the shore birds, with moderately large hearts and pectoralis and large wings with high aspect ratio, would be good fliers.

The large wings, high aspect ratio, but rather moderate pectoralis and fair-sized heart of larids suggest soarers. In the columbids, large pectoralis, large wings, but moderate aspect ratio and fair-sized hearts, with good tails, indicate good flying. Parrots as well as some columbids have fair-sized legs and good flight mechanisms. Cuckoos could not use their wings as much as some birds do, since they possess small pectoral muscles and small hearts. With their large wings, the beat need not be fast. The large wings of owls, moderate hearts and pectoral muscles, together with large legs, enable them to pounce noiselessly and seize prey. The large wings and fairly large pectoral muscles of the goatsuckers, together with rather small legs, suggest a life in the air for the capture of prey.

In the hummingbird, with tiny legs, large pectoralis, supracoracoideus, and heart, and wings with a high aspect ratio, together with large tail and glide area, we have the most capable and most active of the airborne birds. It possesses both speed and maneuverability. It hovers, flies in any direction, flies like an arrow or, on long trips over water, describes an undulating course (Murphy, 1913). Trogons, with somewhat broader but large wings and moderate hearts, would be good fliers, while kingfishers, with smaller pectoral muscles than the trogons, would be less powerful. The small heart of the motmot indicates little sustained activity, which would also be true for the puffbird. Barbets, with large legs and small pectoral muscles, suggest more footwork. Toucans likewise possess less powerful pectoral muscles and large legs.

In the woodpecker large, broad wings and a moderately powerful pectoralis enable it to flap and glide alternately. Its sizable legs suggest active use. The woodhewer is similar, except that a somewhat smaller heart could support less activity. In the ovenbird, the larger heart and a smaller pectoralis, together with larger legs, go with greater activity in the form of less flying and more footwork. In similar fashion the antbird seems to be adapted to ground activity. The cotingas and flycatchers have large, powerful wings, with medium to small legs and moderate hearts.

Large wings with a high aspect ratio and a very large heart are found in the very active swallow. The various values for the crows and jays suggest moderate activity. Many of the small perchers can be included in the classification of the large, broad-winged kinds but with varied pectoral muscles and leg power. The wrens have large legs and small pectorals. The thrushes should be better fliers, using their legs less. The troupials make much use of their legs, as do also some finches.

Among all these birds two groups are most striking: The timamous, with large flight muscles, large lower-extremity muscles, and the smallest hearts; and the hummingbirds, with the largest hearts, large flight muscles, and very small lower-extremity muscles.

Our data show that muscle weights are just as characteristic as is body weight, and this, coupled with the values of certain muscle groups, helps to identify the species. Beddard (1898) said, "the muscular system of birds is remarkably constant for the species." He was referring to the presence and arrangement of the individual muscles.

Although the size of a muscle is inherited through many generations and is usually related to the activity, this is not always so. In a comparison of domesticated and wild forms in the same families, we find that in the domesticated parakeet, *Melopsitticus undulatus,* the various values are similar to those of the wild forms, while in the domestic fowl, *Gallus gallus,* the pectoral muscles and wings are much smaller, but the leg muscles are equal to those in wild species of the family. Although the parakeet leads a rather inactive life, it is not far removed from its wild ancestor. On the other hand the domestic fowl has passed through countless generations of selective breeding.

In conclusion, our observations show that muscle weights are related to the activities of the bird. Since the heart is the driving force that circulates oxygen and nutrients and removes waste products, a small heart limits activity, while a large heart can maintain it much longer. In other words, heart size indicates staying power. The flight muscles tend to parallel the performance in the air, or at least the ability to perform. The area of the wings together with their aspect ratio gives further indication of their use. Finally, the relative weight of a muscle or group of muscles, and the wing areas together with their aspect ratios, appear to be just as characteristic of a species as is the body weight.

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TABLE 1.—*Data obtained in the present study of the locomotor mechanism of birds* (Species marked with an asterisk give typical values for each family as used in drawing the figures. Figures in parentheses indicate the number of individuals of the species.)

	Body weight *grams*	Heart *% body weight*	Upper extremities *% body weight*	Lower extremities *% body weight*	Wings *cm.² per gram*	Aspect ratio
TINAMIDAE						
Tinamus major	1♀ 1175 4♂ 1168±61	(5)0.19±0.03	(3)40.73±2.39	(4)13.0±0.18	(4)0.89±0.06	(4)1.49±0.03
Nothocercus bonapartei	1♀ 1050 4♂ 844±18.1	(3)0.25±0.02	...	17.5, 18.2	(4)1.04±0.05	(4)1.46±0.03
**Crypturellus soui*	6♀ 245±4 8♂ 225±6	(12)0.25±0.01	(6)37.33±1.26	(8)13.90±0.74	(12)1.33±0.04	(12)1.62±0.03
PODICIPEDIDAE						
**Podiceps dominicus*	12♀ 116±3.42 12♂ 129±3.29	(19)1.05±0.04	(5)14.30±0.42	(8)15.85±0.48	(11)1.48±0.04	(11)2.51±0.06
Podilymbus podiceps	6♀ 321±19 5♂ 411±37	(7)1.00±0.05	9.45, 13.63	(3)18.5±0.70	(5)0.86±0.06	(5)2.91±0.12
PELECANIDAE						
**Pelecanus occidentalis*	47♀ 3174±48 56♂ 3702±52	6♀ 0.72±0.06 8♂ 0.89±0.05	2♀ 14.99, 15.94 6♂ 19.48±0.18	2♀ 4.48, 4.52 6♂ 5.66±0.26	(12)1.19±0.06	(12)3.89±0.08
PHALACROCORACIDAE						
Phalacrocorax auritus	32♀ 1540±38 33♂ 1808±39	(11)0.91±0.03	4♀ 17.00±0.80	(4)12.1±0.50	(11)0.97±0.05	(11)2.86±0.13
*Phalacrocorax *olivaceus*	3♀ 1070±67 10♂ 1260±4	(7)0.91±0.03	(5)17.68±0.55	(6)10.73±0.46	(7)1.07±0.09	(6)2.68±0.04

	Upper extremities: Pectoral and sup. *% body weight*	Upper extremities: Pectoralis *% body weight*	Upper extremities: Supra-coracoideus *% body weight*	"Rest" *% body weight*	Tail *cm.² per gram*	Glide *cm.² per gram*	Buoyancy index
TINAMIDAE							
Tinamus major	(4)32.33±1.37	(3)25.2±1.46	(7)7.91±0.23	(3)7.62±0.70	(4)0.07±0.01	(4)1.11±0.05	2.96
Nothocercus bonapartei	(4)21.85±0.83	...	...	...	(4)0.05±0.01	(4)1.24±0.06	3.14
**Crypturellus soui*	(12)29.49±0.68	(7)22.46±1.20	(7)7.55±1.36	(6)6.83±0.23	(12)0.09±0.02	(12)1.62±0.03	2.86
PODICIPEDIDAE							
**Podiceps dominicus*	(7)11.14±0.20	(5)9.86±0.19	(5)1.41±0.19	(5)2.91±0.23	...	(11)1.83±0.04	2.72
Podilymbus podiceps	(5)9.97±1.40	4.83, 5.24	0.68, 0.77	2.07, 3.44	0.02, 0.05	(5)1.13±0.08	2.48
PELECANIDAE							
**Pelecanus occidentalis*	6♀ 12.46±0.65 8♂ 14.07±0.29	2♀ 8.70, 9.86 6♂ 12.1±0.22	2♀ 1.49, 1.51 6♂ 1.99±0.04	2♀ 4.57, 4.80 6♂ 5.41±0.24	(14)0.09±0.01	(12)1.39±0.07	4.22
PHALACROCORACIDAE							
Phalacrocorax auritus	(11)12.16±0.34	4♀ 11.3±0.70	4♀ 1.04±0.03	4♀ 4.61±0.37	(11)0.11±0.01	(11)1.24±0.07	3.40
*Phalacrocorax *olivaceus*	(7)12.72±0.17	(5)11.51±0.17	(5)1.07±0.06	(5)5.10±0.26	(7)0.15±0.01	(7)1.38±0.10	3.27

	Body weight *grams*	Heart *% body weight*	Upper extremities *% body weight*	Lower extremities *% body weight*	Wings *$cm.^2$ per gram*	Aspect ratio
ANHINGIDAE						
**Anhinga anhinga*	14♀ 1227±32.1 12♂ 1244±44.6	(22)0.89±0.03	(5)21.99±0.30	(7)9.01±0.30	(13)1.31±0.04	(14)2.69±0.04
FREGATIDAE						
**Fregata magnificens*	6♀ 1667±29.4 16♂ 1281±8.7	(2)0.81, 1.03	...	...	2.52, 3.06	3.67, 4.38
ARDEIDAE						
Ardea herodias wardi	15♀ 2204±87 17♂ 2576±72.5	(19).83±0.02	...	(2)9.3, 12.0	(7)2.06±0.13	2.63±0.05
Butorides virescens (Florida)	20♀ 212±3.6 14♂ 211±4.7	(10)0.83±0.04	...	...	2.85±0.09	(14)2.34±0.08
Butorides virescens (Panamá)	6♀ 175±9.29 2♂ 156, 157	(8)0.70±0.03	(3)20.52±0.90	(3)10.78±0.21	(6)3.25±0.18	(6)2.43±0.08
Florida cacrulea (Florida)	3♀ 378±40 2♂ 375, 390	(5).83±0.05	...	...	(5)2.95±0.11	(5)2.6±0.04
Florida caerulea (Panamá)	3♀ 288±32.2 8♂ 341±12.5	(13).71±0.018	(4)22.28±0.34	(5)10.6±0.35	(10)3.42±0.07	(10)2.66±0.01
Bubulcus ibis	7♀ 341.5±11.6 2♂ 295, 351	(9).88±0.02	(9)23.54±0.47	(9)8.97±0.22	(8)3.05±0.27	(7)2.69±0.08

	Upper extremities						
	Pectoral and sup. *% body weight*	Pectoralis *% body weight*	Supra-coracoideus *% body weight*	"Rest" *% body weight*	Tail *$cm.^2$ per gram*	Glide *$cm.^2$ per gram*	Buoyancy index
ANHINGIDAE							
**Anhinga anhinga*	(13)14.38±0.30	(5)14.10±2.7	(5)1.30±0.15	(6)6.07±0.38	(13).32±0.03	(13)1.79±0.06	3.7
FREGATIDAE							
**Fregata magnificens*	(2)13.7, 17.4	...	...	...	2.38, 2.88	2.94, 3.59	5.48
ARDEIDAE							
Ardea herodias wardi	(8)13.94±0.72	(1)15.0	1.06	7.11	0.12±0.01	2.32±0.13	5.28
Butorides virescens (Florida)	(10)14.2±0.45	...	...	...	0.16±0.013	3.0±0.13	4.12
Butorides virescens (Panamá)	(6)13.53±0.61	(3)12.65±0.77	(3)1.21±0.19	(3)6.67±0.58	(6)0.19±0.019	(6)3.75±0.21	4.24
Florida caerulea (Florida)	(5)14.2±0.01	...	...	...	0.19±0.02	3.38±0.14	4.62
Florida caerulea (Panamá)	(11)15.12±0.22	(4)14.5±0.26	(4)1.24±0.10	(4)6.55±0.34	(10)0.22±0.02	(10)3.86±0.07	4.87
Bubulcus ibis	(9)16.42±0.37	14.85±0.37	1.59±0.08	(9)7.12±0.15	(7)0.18±0.02	(8)3.50±0.11	6.40

(continued)

TABLE 1.—*continued*

	Body weight *grams*	Heart *% body weight*	Upper extremities *% body weight*	Lower extremities *% body weight*	Wings *cm.² per gram*	Aspect ratio
**Casmerodius albus*	9♀ 812±28.1 P<0.05 12♂ 935±38.8	(16)0.77±0.023	(5)22.29±0.81	(7)10.4±0.14	(13)2.82±0.10	(13)2.60±0.04
Leucophoyx thula	5♀ 348±22.7 12♂ 380.7±18.4	(6)0.78±0.05	(5)21.53±0.51	(6)8.21±1.10	(6)3.41±0.15	(6)2.54±0.06
Hydranassa tricolor	5♀ 334±21.2 35♂ 415±7.66	(25).86±0.28	(3)22.81±0.440	11.3±1.73	(20)3.09±0.063	2.58±0.03
Agamia agami	1♀ 475 3♂ 535±9.35	(2)0.67, 0.72	(1)29.17	(1)11.9	(1)2.73	(1)2.38
Nycticorax nycticorax	2♀ 775,780 2♂ 725, 780	(4)0.73±0.02	. . .	12.15	2.42±0.08	2.49±0.02
Tigrisoma lineatum	6♀ 823±22 5♂ 897±12.44	(11).69±0.023	(4)25.81±0.93	(4)12.06±0.27	(7)2.09±0.04	(7)2.02±0.03
Heterocnus mexicanus	4♀ 1046±49.3 3♂ 1274±110	(7)0.57±0.02	(5)21.69±1.00	(5)11.3±0.30	(7)1.89±0.084	(7)2.12±0.04
Ixobrychus exilis	6♀ 83.69±3.78 14♂ 87.4±1.96	(4)0.815±0.03 P<0.01 (Fla.) (6)0.55±0.03 (Pan.)	(3)13.89±0.11	(3)12.16±0.17	(7)3.09±0.06	(8)2.18±0.05
COCHLEARIIDAE **Cochlearius cochlearius*	3♀ 530±18.7 4♂ 584±16.3	(6).77±0.021	(5)25.13±0.43	(6)10.69±0.24	(6)2.72±0.10	(6)2.10±0.04

	Upper extremities: Pectoral and sup. *% body weight*	Upper extremities: Pectoralis *% body weight*	Upper extremities: Supra-coracoideus *% body weight*	"Rest" *% body weight*	Tail *cm.² per gram*	Glide *cm.² per gram*	Buoyancy index
**Casmerodius albus*	(13)13.56±0.31	(5)13.04±0.54	(6)1.17±0.04	(5)7.68±0.31	(13)0.15±0.01	(13)3.12±0.11	5.19
Leucophoyx thula	(5)14.40±0.55	(3)12.3±1.29	(5)1.26±0.07	(6)6.85±0.26	(6)0.16±0.04	(6)3.82±0.08	5.11
Hydranassa tricolor	(19)13.97±0.25	(3)13.8±0.6	(3)1.18±0.22	(3)7.77±0.49	(19)0.15±0.01	(19)3.44±0.07	4.77
Agamia agami	(1)20.03	(1)18.4	(1)1.63	(1)9.14	(1)0.17	(1)3.11	4.64
Nycticorax nycticorax	(4)14.3±0.29	. . .	. . .	. . .	0.16±0.02	2.69±0.09	4.71
Tigrisoma lineatum	(9)17.02±0.43 P<0.05	(4)15.40±0.96	(4)1.43±0.03	(4)8.99±0.19	(7)0.11±0.00	(7)2.32±0.06	4.38
Heterocnus mexicanus	(7)14.85±0.79	(5)12.41±0.58	(5)1.19±0.10	(5)8.08±0.37	(7)0.08±0.01	(7)2.06±0.04	4.43
Ixobrychus exilis	(2)9.55, 10.10 (Fla.) (6)9.34±0.22 (Pan.)	(3)8.39±0.04 (Pan.)	(3)1.39±0.22 (Pan.)	(3)4.11±0.21 (Pan.)	(7)0.37±0.12	(8)3.54±0.11	3.68
COCHLEARIIDAE **Cochlearius cochlearius*	(6)15.97±0.32	(5)14.53±0.19	(5)1.71±0.13	(5)8.80±0.21	(6)0.12±0.01	(6)3.02±0.08	4.84

	Body weight *grams*	Heart *% body weight*	Upper extremities *% body weight*	Lower extremities *% body weight*	Wings $cm.^2$ *per gram*	Aspect ratio
Cochlearius cochlearius, immature	1♀ 520 2♂ 505,515	(3)0.59±0.4	(3)10.99±0.97	(3)9.6±0.28	...	...
CICONIIDAE						
**Mycteria americana*	1♀ 2050 9♂ 2702±250	(10)0.82±0.05	(3)27.29±0.28	(4)10.9±0.02	(6)1.54±0.07	(6)2.85±0.07
THRESKIORNITHIDAE						
**Eudocimus albus*	18♀ 718±15.65 12♂ 908±31.30	(19)1.02±0.03	(1)31.32	8.48	(13)1.65±0.02	(14)2.33±0.05
ANATIDAE						
Cairina moschata (domestic)	3♀ 2022±39.4 3♂ 2915±115	(6)0.79±0.05	3♀ 23.51±0.54 P<0.01 3♂ 20.85±0.47	3♀ 9.52±0.08 P<0.01 3♂ 10.85±0.12	(6)0.84±0.03	(6)2.16±0.01
Anas acuta	3♀ 568±19.8 1♂ 675	(4)1.23±0.05	(4)31.36±1.56	(4)5.69±0.13	(4)1.13±0.07	(4)3.37±0.07
Anas discors	3♀ 365±10.4 8♂ 333±9.3	(5)1.15±0.03	(4)29.24±0.41	(4)4.85±0.32	(4)1.16±0.04	(4)2.84±0.13
Mareca americana	1♀ 545	0.98	27.17	5.82	1.08	2.75
**Aythya affinis*	7♀ 577±35.3 11♂ 621±22.6	(15)0.90±0.03	(7)22.38±0.96	(8)6.67±0.37	(10)0.79±0.03	(10)3.10±0.10
Oxyura dominica	3♀ 368±23.6 4♂ 359±36	(7)1.12±0.06	...	(1)7.77	(5)0.97±0.08	2.47±0.14

	Upper extremities: Pectoral and sup. *% body weight*	Upper extremities: Pectoralis *% body weight*	Upper extremities: Supra-coracoideus *% body weight*	"Rest" *% body weight*	Tail $cm.^2$ *per gram*	Glide $cm.^2$ *per gram*	Buoyancy index
Cochlearius cochlearius, immature	(3)5.55±0.30	(3)4.82±0.24	(3)0.73±0.09	(3)5.45±0.66	...	...	...
CICONIIDAE							
**Mycteria americana*	(6)18.4±0.41	(3)17.6±0.61	(3)1.30±0.09	(3)8.37±0.58	(6)0.10±0.00	(6)1.76±0.08	4.62
THRESKIORNITHIDAE							
**Eudocimus albus*	(13)20.16±0.43	19.40	2.24	9.68	(14)0.10±0.01	(13)1.96±0.05	3.85
ANATIDAE							
Cairina moschata (domestic)	3♀ 17.30±0.27 P<0.05 3♂ 14.95±0.58	3♀ 15.25±0.31 P<0.01 3♂ 13.09±0.44	3♀ 2.08±0.06 3♂ 1.86±0.14	3♀ 6.20±0.28 3♂ 6.23±0.31	(6)0.14±0.03	(6)1.09±0.02	3.36
Anas acuta	(4)24.26±0.22	(4)21.3±0.35	(4)2.94±0.29	(4)7.11±0.62	(4)0.07±0.01	(4)1.45±0.09	3.10
Anas discors	(4)22.41±0.30	(4)19.64±0.21	(4)2.77±0.09	(4)6.83±0.27	(4)0.11±0.03	(4)1.55±0.07	2.84
Mareca americana	20.77	18.38	2.39	6.40	0.12	1.45	2.55
**Aythya affinis*	(11)17.24±0.60	(7)14.7±0.64	(7)1.94±0.11	(7)5.70±0.34	(10)0.05±0.01	(10)1.07±0.04	2.62
Oxyura dominica	(5)19.7±0.47	...	...	...	0.18±0.01	1.33±0.11	2.63

(continued)

TABLE I.—*continued*

	Body weight *grams*	Heart *% body weight*	Upper extremities *% body weight*	Lower extremities *% body weight*	Wings *cm.² per gram*	Aspect ratio
CATHARTIDAE						
Coragyps atratus (Florida)	1♀ 1950 5♂ 2065±76	(8)0.89±0.03 P<.05	...	...	1.59±0.06	2.20±0.15
**Coragyps atratus* (Panamá)	3♀ 1865±82.7 4♂ 1775±127	(7)0.79±0.03	(5)25.02±1.24	(6)15.0±0.65	(7)1.54±0.10	(7)2.31±0.03
Cathartes aura (Florida)	5♀ 1589±118.35 15♂ 1426±10	(15)0.74±0.02	...	...	2.98±0.10	2.65±0.04
Cathartes aura (Panamá)	3♀ 1458±208 6♂ 1175±58.9 smaller than Fla. P<0.01	(9)0.66±0.01 smaller than Fla. P<0.01	(3)28.86±0.79	(3)9.90±0.68	(4)3.15±0.23	(4)2.63±0.06
ACCIPITRIDAE						
Elanoïdes forficatus	2♂ 445, 505	0.81, 0.81	(1)23.30	4.67, 5.14	2.72, 3.28	3.37, 3.48
Leptodon cayanensis	1♀ 540 2♂ 435, 445	(3)0.43±0.04	(1)31.45	(2)9.06, 10.11	(3)3.29±0.31	(3)2.01±0.09
Chondrohierax uncinatus	3♀ 296±22.2 4♂ 265±11.6	(7)0.56±0.01	(6)29.92±0.56	(7)7.54±0.10	(6)5.24±0.14	(7)1.94±0.02
Harpagus bidentatus	1♀ 206.0 1♂ 165.0	(1)0.49	...	...	3.44	2.01
Accipiter bicolor	♂ 235	1.28	...	10.3	3.17	2.01

	Upper extremities						
	Pectoral and sup. *% body weight*	Pectoralis *% body weight*	Supra-coracoideus *% body weight*	"Rest" *% body weight*	Tail *cm.² per gram*	Glide *cm.² per gram*	Buoyancy index
CATHARTIDAE							
Coragyps atratus (Florida)	(8)16.0±0.44	...	...	...	0.15±0.01	1.99±0.11	4.50
**Coragyps atratus* (Panamá)	(6)16.39±0.43	(5)14.33±0.76	(4)1.31±0.19	(5)9.38±0.31	(7)0.18±0.01	(7)1.91±0.07	4.47
Cathartes aura (Florida)	(11)15.8±0.21 P<0.01	...	...	...	0.43±0.01	3.90±0.16	5.81
Cathartes aura (Panamá)	(4)17.45±0.51	(3)16.4±0.64	(3)1.26±0.03	(3)11.2±0.13	(4)0.53±0.04	(4)3.94±0.27	5.86
ACCIPITRIDAE							
Elanoïdes forficatus	14.0, 14.29	13.90	0.39	9.02	0.58, 0.66	3.66, 4.06	4.84
Leptodon cayanensis	(3)16.60±2.23	(1)14.56	(1)5.65	(1)11.24	(3)0.65±0.10	(3)4.14±0.39	4.79
Chondrohierax uncinatus	(7)18.30±0.29	(6)17.64±0.32	(6)0.68±0.05	(6)11.61±0.36	(7)1.11±0.08	(6)6.99±0.16	5.56
Harpagus bidentatus	(1)17.65	16.87	0.78	...	0.83	4.55	4.51
Accipiter bicolor	22.00	...	...	...	0.77	4.13	4.42

	Body weight *grams*	Heart *% body weight*	extremities *% body weight*	extremities *% body weight*	*cm.² per gram*	Aspect ratio
Accipiter cooperii	6♀ 535±19 1♂ 315	0.81	...	...	2.54	2.19
Accipiter striatus	1♀ 171.0	0.73	...	10.2	3.49	2.18
Heterospizias meridionalis	2♀ 800, 866 5♂ 776±33.5	(4)0.69±0.06	18.09, 25.09	(4)14.08±0.67	(4)2.97±0.25	(4)2.35±0.18
Buteo lineatus	14♀ 643±25.7 10♂ 475±25.6	(7)0.55±0.03	(1)22.71	(1)15.9	3♀ 2.46±0.14 5♂ 3.14±0.16 P<0.05	(8)2.24±0.06
**Buteo platypterus*	4♀ 412±14 12♂ 359.6±8.7	(9)0.54±0.02	(5)21.39±0.78	(6)13.96±0.25	(7)2.70±0.10	(7)2.28±0.02
Buteo magnirostris	7♀ 272±11.68 9♂ 266±8.6	(13)0.56±0.02	(4)21.70±0.09	(7)13.8±0.26	(12)2.97±0.07	(2)2.01±0.03
Buteo nitidus	1♀ 420	0.40	...	...	2.59	2.21
Busarellus nigricollis	2♀ 895, 900 1♂ 725	(3)0.65±0.03	...	15.2	3.21±0.12	1.98±0.03
Buteogallus anthracinus	4♀ 1199±142 6♂ 793±95.8	(8)0.57±0.03	(3)22.21±0.56	(5)17.6±0.96	(8)2.60±0.20	(8)2.07±0.05
Hypomorphnus urubitinga	2♀ 625, 900	(2)0.40, 0.48	...	15.4	2.95, 3.08	1.99, 2.41
Spizastur melanoleucus	1♀ 525	0.42	26.41	10.5	(1)2.76	1.95

	Upper extremities						
	Pectoral and sup. *% body weight*	Pectoralis *% body weight*	Supra-coracoideus *% body weight*	"Rest" *% body weight*	Tail *cm.² per gram*	Glide *cm.² per gram*	Buoyancy index
Accipiter cooperii	13.3	...	...	...	0.54	3.32	4.50
Accipiter striatus	22.2	...	...	...	1.14	4.84	4.40
Heterospizias meridionalis	(2)13.99, 0.74	12.2, 15	0.38, 0.59	6.35, 9.50	(4)0.26±0.04	(4)3.45±0.22	5.29
Buteo lineatus	3♀ 13.60±0.88 5♂ 11.31±0.74	...	(1)0.47	(1)7.74	(8)0.56±0.05	3♀ 3.19±0.23 5♂ 4.00±0.22	4.76
**Buteo platypterus*	(7)13.76±0.57	(5)12.81±0.58	(5)0.42±0.05	(5)7.59±0.27	(7)0.59±0.07	(7)3.59±0.17	4.35
Buteo magnirostris	(12)12.79±0.27	(4)12.65±0.35	(4)0.45±0.04	(5)7.59±0.27	(12)0.62±0.03	(12)3.78±0.08	4.36
Buteo nitidus	12.28	...	...	...	0.62	3.38	
Busarellus nigricollis	(3)13.9±0.33	...	...	...	0.26±0.01	3.61±0.14	5.50
Buteogallus anthracinus	(8)13.52±0.44	(3)13.05±0.37	(3)0.52±0.03	(3)8.71±0.36	(8)3.8±0.04	(8)3.10±0.24	5.06
Hypomorphnus urubitinga	(2)12.5, 12.8	...	...	...	...	3.44, 3.51	5.19
Spizastur melanoleucus	15.61	15.05	0.56	10.8	0.58	3.64	4.72

(continued)

TABLE 1.—*continued*

	Body weight *grams*	Heart *% body weight*	Upper extremities *% body weight*	Lower extremities *% body weight*	Wings *cm.² per gram*	Aspect ratio
Spizaëtus ornatus	1♂ 1215	0.35	29.33	17.1	(1) 1.75	1.74
Geranospiza caerulescens	1♀ 430 1♂ 325	(2) 0.61, 0.69	18.86, 20.97	17.0, 18.6	(2) 3.82, 3.25	2.02, 1.91
PANDIONIDAE						
**Pandion haliaetus*	3♀ 1837±235 2♂ 1530, 1500	(1) 0.84	24.79	8.5	(1) 2.16	3.00
FALCONIDAE						
Herpctotheres cachinnans	1♀ 800 1♂ 675	(2) 0.71, 0.49	23.14, 22.14	14.05, 15.05	2.41, 1.53	2.17, 2.08
Micrastur ruficollis	6♀ 196±6.62 6♂ 161±2.44	(11) 0.60±0.03	3♀ 21.43±0.46 3♂ 23.21±0.20	(8) 18.59±0.49	(8) 2.83±0.11	(8) 1.72±0.04
Micrastur semitorquatus	1♀ 900	0.62	25.63	23.5	1.72	1.58
Milvago chimachima	1♀ 410 1♂ 325	0.65, 0.75	...	11.3, 12.0	2.85, 3.65	2.34, 2.41
**Caracara cheriway*	10♀ 953±20.0 P<0.01 14♂ 834±35.5	(12) 1.11±0.04	(3) 23.22±0.09	(4) 12.9±0.54	(11) 2.02±0.07	2.60±0.04
Falco peregrinus	2♀ 825, 825	(1) 1.23	29.92	12.0	(1) 1.69	3.06

	Upper extremities: Pectoral and sup. *% body weight*	Upper extremities: Pectoralis *% body weight*	Upper extremities: Supra-coracoideus *% body weight*	"Rest" *% body weight*	Tail *cm.² per gram*	Glide *cm.² per gram*	Buoyancy index
Spizaëtus ornatus	13.93	13.50	0.43	15.4	0.45	2.42	4.32
Geranospiza caerulescens	12.51, 11.27	12.1, 10.9	0.37, 0.41	7.59, 8.46	0.77, 1.18	5.51, 5.25	5.25
PANDIONIDAE							
**Pandion haliaetus*	14.69	14.0	0.69	10.10	0.18	2.49	5.05
FALCONIDAE							
Herpetotheres cachinnans	13.48, 14.79	13, 14	0.48, 0.79	8.66, 8.35	0.45, 0.43	3.05, 2.18	4.66
Micrastur ruficollis	6♀ 12.80±0.16 4♂ 14.56±0.17	4♀ 12.11±0.20 4♂ 13.7±0.77	5♀ 0.73±0.01 P<0.01 4♂ 0.85±0.01	(6) 8.72±0.13	(8) 0.78±0.08	(8) 3.94±0.20	4.01
Micrastur semitorquatus	16.99	15.95	1.04	8.64	0.67	2.61	4.07
Milvago chimachima	14.1, 15.2	14.1, 15.2	...	...	0.62, 0.80	3.60, 4.60	4.79
**Caracara cheriway*	(11) 15.4±0.09	(3) 14.4±0.64	0.64±0.04	(3) 8.21±0.57	0.35±0.02	2.53±0.07	4.42
Falco peregrinus	19.20	18.2	0.82	10.9	0.37	2.19	3.98

	Body weight *grams*	Heart *% body weight*	Upper extremities *% body weight*	Lower extremities *% body weight*	Wings *cm.² per gram*	Aspect ratio
Falco albigularis	1♂ 149.9	1.07	24.68	9.04	1.98	3.05
Falco sparverius	11♀ 112.5±3.43 4♂ 85.7±7.42	(15)1.01±0.03	(5)21.82±0.55	(8)8.54±0.22	(11)3.49±0.09	(11)2.63±0.04
CRACIDAE *Ortalis garrula*	1♀ 470 6♂ 541±25.5	(7)0.62±0.04	(5)23.20±0.53	(6)19.86±0.58	(7)1.63±0.07	(7)1.51±0.04
**Chamaepetes unicolor*	7♀ 1148±51.9 5♂ 1116±78.6	(10)0.48±0.02	(1)26.46	(2)15.7, 15.7	(5)1.36±0.11	(5)1.38±0.07
PHASIANIDAE *Colinus virginianus floridanus*	2♀ 150, 170 8♂ 150±5.28	(10)0.38±0.02	(4)34.31±0.60	(4)14.6±0.60	(4)1.19±0.03	(4)1.74±0.10
**Odontophorus guttatus*	4♀ 294±5.95 18♂ 314±5.10	(11)0.34±0.01	(5)30.02±0.97	(6)16.38±0.56	(9)1.26±0.03	(8)1.56±0.06
Coturnix coturnix japonica	3♀ 123.48±4.2	(3)1.00±0.08	(3)25.60±0.08	(3)12.16±0.85	(3)1.13±0.04	(3)2.15±0.07
Gallus gallus (White Leghorn)	10♀ 1705±48.3 P<0.01 10♂ 2430±54.0	10♀ 0.36±0.01 P<0.01 10♂ 0.50±0.01	(1)16.56	7♀ 12.5±0.39 P<0.01 7♂ 17.1±0.89	(20)0.53±0.02	(20)1.31±0.02
(Buff Orpington)	2♀ 2846, 3126	(2)0.32, 0.38	...	(2)6.92, 7.23	(2)0.30, 0.32	1.48, 1.53

	Upper extremities: Pectoral and sup. *% body weight*	Upper extremities: Pectoralis *% body weight*	Upper extremities: Supra-coracoideus *% body weight*	"Rest" *% body weight*	Tail *cm.² per gram*	Glide *cm.² per gram*	Buoyancy index
Falco albigularis	16.96	16.35	0.61	7.72	0.35	2.58	3.25
Falco sparverius	(13)15.0±0.33	(7)14.82±0.39	(7)0.59±0.03	(7)6.92±0.17	1.05±0.06	(11)4.92±0.16	4.04
CRACIDAE *Ortalis garrula*	(7)15.05±0.39	(5)12.83±0.63	(5)2.28±0.13	(5)8.09±0.18	(7)0.74±0.03	(7)2.55±0.07	3.68
**Chamaepetes unicolor*	(5)16.6±0.41	14.7	3.30	8.46	(5)0.52±0.02	(5)2.05±0.18	3.66
PHASIANIDAE *Colinus virginianus floridanus*	(4)28.79±0.47	(4)21.6±0.55	(4)7.16±0.10	(4)5.53±0.32	(4)0.24±0.01	(4)1.70±0.04	2.62
**Odontophorus guttatus*	(8)24.06±0.50	(6)18.06±0.63	(6)5.89±0.29	(5)6.17±0.40	(8)0.13±0.01	(9)1.54±0.03	3.10
Coturnix coturnix japonica	(3)21.14±0.12	(3)15.49±0.32	(3)5.66±0.40	(3)4.46±0.14	(3)0.04±0.01	(3)1.49±0.06	2.38
Gallus gallus (White Leghorn)	(20)10.6±0.23	(1)8.78	3.50	4.28	(15)0.08±0.02	(17)0.85±0.02	2.60
(Buff Orpington)	(2)5.53, 5.85	...	...	...	0.73, 0.78	...	2.11

(continued)

TABLE 1.—*continued*

	Body weight *grams*	Heart *% body weight*	Upper extremities *% body weight*	Lower extremities *% body weight*	Wings *cm.² per gram*	Aspect ratio
NUMIDIDAE *Numida meleagris	7♀ 1299±41.64 3♂ 1299±25.23	(10)0.57±0.02	(10)24.97±0.28	(10)16.6±0.20	(10)0.90±0.02	(10)1.48±0.02
ARAMIDAE *Aramus guarauna	3♀ 863±16.1 P<0.01 3♂ 1028±13.0	(6)0.71±0.04	(2)24.12, 21.39	16.2, 16.9	1.36, 1.74	2.20, 2.90
RALLIDAE *Aramides cajanea*	13♀ 385±20.0 5♂ 427±22.7	(11)0.59±0.02	(7)15.93±0.65	(6)23.16±1.14	(8)1.50±0.05	(8)1.67±0.04
*Laterallus albigularis	12♀ 44.99±1.83 13♂ 49.68±1.60	(20)0.61±0.02	(6)11.97±0.67	(7)17.41±0.60	(16)2.32±0.09	(16)1.65±0.04
Gallinula chloropus	10♀ 312±11.0 10♂ 356±22.0	(15)0.58±0.03	(3)16.31±0.85	(4)16.1±0.51	(11)1.26±0.06	(11)2.09±0.03
Porphyrula martinica	8♀ 215±6.34 P<0.01 20♂ 257±6.05	(23)0.63±0.02	(3)13.66±0.52	(5)15.7±0.76	(14)1.61±0.05	(14)2.29±0.04
Fulica americana	14♀ 460±14.2 11♂ 562±26.7	(11)0.65±0.04	(3)13.47±0.31	(3)11.4±0.88	(9)1.00±0.03	(9)2.32±0.10
HELIORNITHIDAE *Heliornis fulica	3♀ 129.9±3.10 4♂ 139.8±2.4	(6)0.67±0.03	(4)17.64±0.56	(5)14.90±0.73	(5)1.83±0.05	(5)2.07±0.03

	Upper extremities: Pectoral and sup. *% body weight*	Upper extremities: Pectoralis *% body weight*	Upper extremities: Supra-coracoideus *% body weight*	"Rest" *% body weight*	Tail *cm.² per gram*	Glide *cm.² per gram*	Buoyancy index
NUMIDIDAE *Numida meleagris	(10)18.83±0.22	(10)14.31±0.14	(10)4.51±0.13	(10)6.14±0.13	(10)0.14±0.01	(10)1.19±0.05	3.13
ARAMIDAE *Aramus guarauna	14.28, 14.78	13.0, 13.4	1.28, 1.38	7.11, 9.34	0.12, 0.18	2.03, 2.44	3.59
RALLIDAE *Aramides cajanea*	(8)9.75±0.33	(6)8.62±0.26	(6)1.34±0.13	(6)5.72±0.29	(7)0.06±0.01	(8)1.72±0.05	3.34
*Laterallus albigularis	(17)7.76±0.06	(6)7.01±0.31	(6)1.29±0.14	(6)3.29±0.33	(10)0.11±0.01	(16)2.81±0.11	2.90
Gallinula chloropus	(12)11.63±0.44	(3)10.2±0.45	(3)1.50±0.05	5.39, 5.43	(12)0.11±0.01	(11)1.58±0.06	2.96
Porphyrula martinica	(13)10.83±0.34	(3)8.93±0.21	(3)1.12±0.06	(3)3.61±0.35	(14)0.10±0.01	(12)2.02±0.07	3.15
Fulica americana	(9)9.32±0.40	(3)8.20±0.21	(3)1.24±0.14	(3)4.04±0.33	(6)0.04±0.01	(6)1.25±0.04	2.79
HELIORNITHIDAE *Heliornis fulica	(5)12.36±0.32	(4)10.66±0.34	(4)1.86±0.08	(4)5.12±0.16	(5)0.51±0.06	(5)2.60±0.08	3.04

	Body weight *grams*	Heart *% body weight*	Upper extremities *% body weight*	Lower extremities *% body weight*	Wings *cm.² per gram*	Aspect ratio
JACANIDAE						
**Jacana spinosa*	16♀ 112.0±2.7 20♂ 78.9±1.9	(23)0.77±0.02	5♀ 25.24±0.51 2♂ 17.68, 19.45	4♀ 12.1±0.54 2♂ 9.80, 10.45	(15)2.98±0.10	(14)1.99±0.03
CHARADRIIDAE						
**Charadrius vociferus*	4♀ 86.5±0.48 8♂ 80.96±3.78	(8)1.36±0.05	(1)29.30	7.88	(1)3.34	3.00
SCOLOPACIDAE						
Totanus flavipes	6♀ 91.16±4.34 6♂ 78.15±2.29	(9)1.29±0.04	(7)27.81±0.50	(9)4.64±0.06	(9)2.63±0.14	(8)3.09±0.02
Totanus melanoleucus	4♀ 221±19 5♂ 200±13	(2)1.21, 1.26	(1)30.61	(1)6.57	(1)2.34	(1)3.17
Tringa solitaria	2♀ 54.5, 66.0 3♂ 51.5±10	(3)1.08±0.09	...	(1)6.05	(1)4.16	(1)2.81
Actitis macularia	2♀ 38,45 1♂ 28.6	(3)1.04±0.06	...	...	(1)3.82	(1)2.51
Catoptrophorus semipalmatus	1♀ 250 3♂ 213±24	(1)1.10	(1)30.43	(1)8.91	(1)2.20	(1)2.73
Limnodromus griseus	5♀ 105±2 6♂ 98±2	(5)1.45±0.09	...	...	(1)2.13	(1)2.95
Capella gallinago	5♀ 114.7±0.5 3♂ 99±6	(7)1.22±0.05	(4)31.67±1.20	(5)9.30±0.25	(5)1.95±0.18	(4)2.63±0.12

	Upper extremities						
	Pectoral and sup. *% body weight*	Pectoralis *% body weight*	Supra-coracoideus *% body weight*	"Rest" *% body weight*	Tail *cm.² per gram*	Glide *cm.² per gram*	Buoyancy index
JACANIDAE							
**Jacana spinosa*	9♀ 18.35±0.36 P<0.05 6♂ 16.29±0.64	4♀ 16.21±0.18 2♂ 12.4, 13.3	4♀ 2.83±0.09 2♂ 1.82, 1.98	4♀ 6.35±0.38 2♂ 3.30, 4.33	(12)0.07±0.01	(15)3.33±0.08	3.64
CHARADRIIDAE							
**Charadrius vociferus*	(1)23.04	(1)21.5	(1)2.54	5.26	0.71	4.42	3.83
SCOLOPACIDAE							
Totanus flavipes	(7)23.19±0.33	(7)20.5±0.26	(9)2.59±0.14	(9)4.64±0.06	(9)0.46±0.02	(9)3.79±0.05	3.62
Totanus melanoleucus	(1)25.03	21.6	3.43	5.58	0.31	2.88	3.66
Tringa solitaria	(1)22.20	...	...	...	0.48	4.93	3.82
Actitis macularia	(1)19.8	...	...	...	0.48	4.85	3.44
Catoptrophorus semipalmatus	(1)23.91	21.1	2.81	6.52	0.18	2.73	3.62
Limnodromus griseus	(1)18.8	...	...	...	0.27	2.74	3.12
Capella gallinago	(5)27.86±0.83	(4)22.94±0.79	(4)4.55±0.34	(4)4.19±0.72	(5)0.22±0.02	(4)2.59±0.13	2.90

(continued)

TABLE 1.—*continued*

	Body weight *grams*	Heart *% body weight*	Upper extremities *% body weight*	Lower extremities *% body weight*	Wings *cm.² per gram*	Aspect ratio
Crocethia alba	4♀ 58.14±2.59 6♂ 53.16±0.87	(9)1.54±0.05	(7)26.13±0.28	(7)4.85±0.21	(9)2.89±0.07	(8)3.17±0.07
**Ereunetes mauri*	4♀ 28.33±2.20 9♂ 26.06±0.84	(8)1.26±0.08	(6)22.88±0.38	(6)4.50±0.14	(7)3.70±0.10	(7)2.94±0.07
Erolia melanotos	1♀ 48.9 1♂ 41.0	(2)1.13, 1.25	(2)28.66, 32.40	(2)5.86, 6.10	(2)3.52, 3.93	(2)2.77, 3.00
Erolia alpina	3♀ 57.36±2.32 7♂ 52.36±2.74	(6)1.48±0.04	(6)26.74±0.38	(6)4.75±0.12	(6)2.87±0.09	(6)3.23±0.05
RECURVIROSTRIDAE						
**Himantopus mexicanus*	7♀ 152±10 8♂ 173±5	(15)1.22±0.04	. . .	. . .	(4)2.87±0.28	(4)2.94±0.08
LARIDAE						
Larus delawarensis	4♂ 502±24.1	(3)0.85±0.09	(3)20.43±0.53	(3)5.28±0.17	(3)2.81±0.09	(3)3.75±0.09
Larus argentatus	11♀ 762±34.8 18♂ 907±17.1	(3)0.84±0.06	(2)19.47, 22.46	6.38, 8.20	1.78, 2.11	3.53, 3.88
Larus atricilla	10♀ 299±20.5 36♂ 295±5.5	(13)0.85±0.03	(5)19.81±0.61	(4)4.74±0.37	(10)3.44±0.10	(11)3.46±0.08
Larus pipixcan	2♂ 230, 289	(3)0.68±0.10	(3)17.54±0.70	(3)4.48±0.32	(3)3.33±0.29	(3)3.35±0.09
Sterna hirundo	9♀ 99±2.96 10♂ 115±6.17	(10)1.08±0.05	(3)20.38±0.35	(3)2.72±0.07	(3)3.69±0.25	(3)4.48±0.12

	Upper extremities						
	Pectoral and sup. *% body weight*	Pectoralis *% body weight*	Supra-coracoideus *% body weight*	"Rest" *% body weight*	Tail *cm.² per gram*	Glide *cm.² per gram*	Buoyancy index
Crocethia alba	(9)22.13±0.39	(7)20.0±0.31	(7)2.54±0.11	(6)3.58±0.08	(7)0.42±0.03	(9)3.71±0.10	3.36
**Ereunetes mauri*	(8)19.7±0.36	(6)17.7±0.32	(6)2.37±0.11	(6)2.85±0.10	(7)0.59±0.06	(7)4.76±0.18	3.83
Erolia melanotos	(2)23.8, 26.59	20.50, 22.95	3.32, 3.65	4.84, 5.81	0.57, 0.70	4.50, 4.98	3.65
Erolia alpina	(6)22.98±0.35	(6)20.0±0.28	(6)2.96±0.11	(6)3.75±0.05	(6)0.48±0.02	(6)3.75±0.12	3.31
RECURVIROSTRIDAE							
**Himantopus mexicanus*	(4)17.1±0.15	. . .	. . .	. . .	0.22±0.01	(4)3.38±0.28	4.00
LARIDAE							
Larus delawarensis	(3)14.32±0.16	(3)13.3±0.19	(3)1.02±0.05	(3)6.45±0.41	(3)0.51±0.01	(3)3.59±0.11	4.79
Larus argentatus	(2)12.96, 15.91	11.8, 14.8	1.11, 1.16	6.51, 6.55	0.29, 0.30	2.27, 2.68	4.55
Larus atricilla	(12)12.86±0.31	(5)12.6±0.54	(5)1.04±0.07	(5)6.15±0.18	(12)0.44±0.04	(9)4.18±0.14	4.78
Larus pipixcan	(3)12.24±0.29	(3)11.32±0.27	(3)0.91±0.07	(3)5.30±0.43	(3)0.49±0.08	(3)4.18±0.43	4.63
Sterna hirundo	(3)15.34±0.24	(3)14.0±0.25	(3)1.31±0.12	(3)5.04±0.11	(3)0.44±0.04	(3)4.50±0.32	4.32

	Body weight *grams*	Heart *% body weight*	Upper extremities *% body weight*	Lower extremities *% body weight*	Wings *cm.² per gram*	Aspect ratio
Sterna forsteri	4♀ 117±3.3 3♂ 118±3	(3)1.08±0.14	...	...	3.8, 4.0	3.85, 4.08
**Thalasseus maximus*	11♀ 463±18.6 17♂ 475±6.47	(23)0.98±0.03	(9)20.12±0.44	(9)2.68±0.10	(18)2.06±0.05	(18)4.69±0.14
Thalasseus sandvicensis	1♀ 270 2♂ 330, 210	(4)0.84±0.03	(1)18.74	(1)2.28	(4)2.97±0.16	(4)3.72±0.66
RYNCHOPIDAE						
**Rynchops nigra*	5♀ 235±14.9 8♂ 351±18.5	(10)1.00±0.05	(10)20.75±0.35	(10)2.73±0.09	(10)3.34±0.22	(10)4.42±0.14
COLUMBIDAE						
Columba livia	1♀ 278 6♂ 307±10.63	(7)1.29±0.05	(6)30.90±0.82	(7)6.10±0.16	(7)1.85±0.04	(7)2.28±0.05
Columba albilinea	5♀ 312±9.5 12♂ 309±6.6	(17)1.17±0.03	(3)34.06±2.33	(5)5.54±0.36	(12)1.79±0.04	(12)1.98±0.06
Columba speciosa	6♀ 255±5.8 $P<0.05$ 13♂ 262±3.2	(7)1.25±0.40	(7)37.68±0.85	(8)5.01±0.13	(8)1.56±0.05	(8)1.95±0.03
Columba nigrirostris	2♂ 128, 160	(2)1.24, 1.58	...	(1)6.95	(2)2.19, 2.97	1.80, 1.82
Columba subvinacea	1♀ 150, 157.2 3♂ 180.7±8.43	(5)1.20±0.15	(3)36.45±1.02	(3)5.28±0.15	(4)2.29±0.08	(5)2.00±0.11

	Upper extremities: Pectoral and sup. *% body weight*	Upper extremities: Pectoralis *% body weight*	Upper extremities: Supra-coracoideus *% body weight*	"Rest" *% body weight*	Tail *cm.² per gram*	Glide *cm.² per gram*	Buoyancy index
Sterna forsteri	(2)14.3, 13.6	...	...	...	0.47, 0.53	(2)4.6, 4.8	4.37
**Thalasseus maximus*	(18)14.40±0.21	(9)13.5±0.35	(9)1.19±0.02	(9)5.57±0.13	(18)0.21±0.01	(18)2.51±0.06	3.95
Thalasseus sandvicensis	(4)12.6±0.76	(1)12.8	1.09	4.85	(4)0.38±0.02	(4)3.69±0.24	4.44
RYNCHOPIDAE **Rynchops nigra*	(10)14.29±0.27	(10)13.35±0.24	(10)1.04±0.04	(10)6.46±0.17	(10)0.33±0.02	(10)3.97±0.24	5.00
COLUMBIDAE *Columba livia*	(7)23.50±0.65	(7)20.3±0.54	(7)3.22±0.17	(6)7.18±0.26	(7)0.61±0.06	(7)2.72±0.09	3.52
Columba albilinea	(12)25.16±0.49	(3)21.30±1.62	(3)3.89±0.41	(3)8.87±0.47	(12)0.54±0.02	(12)2.54±0.04	3.49
Columba speciosa	(8)29.07±0.59	(8)25.0±0.57	(7)4.57±0.08	(7)8.38±0.06	(8)0.48±0.03	(8)2.27±0.08	3.16
Columba nigrirostris	(1)28.73	24.15, 36.2	(1)4.58	...	0.61, 1.16	3.07, 4.42	3.66
Columba subvinacea	(5)26.85±0.79	(4)23.1±0.58	4.33±0.11	(3)8.61±0.75	(4)0.85±0.07	(4)3.40±0.18	3.64

(*continued*)

TABLE 1.—*continued*

	Body weight *grams*	Heart *% body weight*	Upper extremities *% body weight*	Lower extremities *% body weight*	Wings *cm.² per gram*	Aspect ratio
Columbigallina passerina	3♀ 41.1±5.2 9♂ 44.0±1.3	(8)1.11±0.05 P<0.05	...	...	2.87±0.15	1.59±0.28
Columbigallina minuta	3♀ 45.57±2.46 1♂ 33.8	(2)1.00, 1.00	(2)33.52, 34.42	5.42, 5.57	2.13, 2.99	1.62, 1.69
**Columbigallina talpacoti rufipennis*	14♀ 47.12±0.85 26♂ 46.74±1.01	(16)0.96±0.04	(5)34.08±0.45	(5)5.39±0.16	(15)2.86±0.05	(15)1.69±0.03
Claravis pretiosa	1♀ 59.56 11♂ 70.97±1.36	(10)1.27±0.04 P<0.01	(5)38.97±1.01	(6)4.53±0.06	(10)2.69±0.05	(10)1.85±0.02
Claravis mondetoura	3♂ 82.93±1.76	(3)1.04±0.08	...	6.62	(3)2.28±0.06	1.74±0.08
Leptotila verreauxi	15♀ 154±3.67 19♂ 152±3.38	(23)0.93±0.02	(7)36.9±0.89	(7)5.31±0.22	(16)2.01±0.06	(16)1.63±0.03
Leptotila cassini	2♀ 131.1, 150 5♂ 157.7±8.3	(10)0.49±0.02	(4)42.35±0.27	(6)5.55±0.17	(6)2.24±0.09	(8)1.82±0.06
Leptotila rufinucha	3♀ 155±1.8 6♂ 170±0.25	(8)0.57±0.01	(5)43.9±0.69	(5)5.63±0.20	(6)1.77±0.05	(6)1.71±0.03
Geotrygon costaricensis	2♀ 225, 283 2♂ 310, 330	0.31, 0.31	37.96	(3)7.81±0.70	(4)1.42±0.16	(4)1.59±0.06
Geotrygon montana	4♀ 128±3 4♂ 141±6.7	(7)1.08±0.06	(7)34.37±1.04	(7)5.72±0.25	(8)2.00±0.09	(8)1.85±0.03
Geotrygon chiriquensis	8♀ 306±7.05 11♂ 309±6.33	(14)0.32±0.02	(5)38.04±0.52	(6)8.84±0.37	(10)1.30±0.03	(10)1.58±0.02

	Upper extremities: Pectoral and sup. *% body weight*	Upper extremities: Pectoralis *% body weight*	Upper extremities: Supra-coracoideus *% body weight*	"Rest" *% body weight*	Tail *cm.² per gram*	Glide *cm.² per gram*	Buoyancy index
Columbigallina passerina	(6)29.3±0.76	...	...	...	(6)0.68±0.04	4.07±0.16	3.17
Columbigallina minuta	27.7, 28.16	22.7, 22.7	5.00, 5.46	5.82, 6.26	0.71, 0.80	3.23, 4.31	3.04
**Columbigallina talpacoti rufipennis*	(14)28.09±0.44	(5)22.76±0.54	(5)5.63±0.27	(5)5.70±0.69	(15)0.72±0.02	(15)3.99±0.06	3.22
Claravis pretiosa	(10)30.92±0.42	(5)26.21±0.44	(5)5.40±0.16	(5)7.36±0.43	(10)0.74±0.05	(10)3.78±0.06	3.31
Claravis mondetoura	(3)30.2±0.92	...	...	...	(3)0.63±0.09	3.20±0.02	3.15
Leptotila verreauxi	(18)30.33±0.37 P<0.01	(9)24.7±0.57	(8)5.99±0.25	(8)6.82±0.55	(15)0.66±0.03	(15)2.96±0.09	3.28
Leptotila cassini	(8)34.16±0.76	(4)27.99±1.25	(4)6.78±0.04	(4)7.58±0.26	(6)0.48±0.05	(5)2.97±0.08	3.47
Leptotila rufinucha	(6)36.65±0.19	(6)29.34±0.47	(6)7.31±0.16	(5)7.36±0.37	(5)0.44±0.02	(6)2.38±0.05	3.11
Geotrygon costaricensis	(4)30.59±1.23	24.35	6.42	7.19	(4)0.23±0.04	(4)1.81±0.20	3.06
Geotrygon montana	(8)26.38±0.60	(8)22.36±0.65	(8)4.65±0.21	(7)7.58±0.22	(8)0.40±0.04	(8)2.66±0.05	2.72

	Body weight *grams*	Heart *% body weight*	Upper extremities *% body weight*	Lower extremities *% body weight*	Wings *cm.² per gram*	Aspect ratio
PSITTACIDAE						
**Pyrrhura hoffmanni*	17♀ 81.8±1.2 17♂ 82.8±3.0	(21)1.41±0.06	(3)27.36±0.16	(4)5.52±0.18	(6)3.17±0.05	(6)1.87±0.05
Brotogeris jugularis	9♀ 65.50±0.13 P<0.05 14♂ 61.00±1.17	(12)1.33±0.05	(4)28.51±0.13	(5)6.30±0.14	(9)2.54±0.07	(9)2.36±0.05
Bolborhynchus lineola	1♀ 53.2 1♂ 45.2	(2)1.58, 1.81	(1)28.92	(1)5.44	(2)2.34, 2.72	(2)2.22, 2.44
Pionopsitta haematotis	4♀ 146.1±6.5 4♂ 145.4±0.6	(7)1.51±0.04	(4)28.66±0.91	(5)6.70±0.14	(7)1.91±0.14	(7)2.22±0.05
Pionus senilis	7♀ 208.9±8.4 4♂ 217±5.0	(7)1.19±0.06	(2)31.28, 29.75	(4)7.24±0.64	(8)2.17±0.10	(8)2.17±0.06
Amazona autumnalis	8♀ 408±10.3 8♂ 424±9.1	(15)1.03±0.03	(5)26.94±1.06	(6)8.00±0.22	(11)1.66±0.07	(14)2.00±0.03
Melopsitticus undulatus	9♀ 33.1±0.19 7♂ 32.9±0.60	9♀ 1.36±0.04 7♂ 1.45±0.07	(16)26.39±1.08	(16)5.54±0.16	(16)2.52±0.11	(16)2.44±0.04
CUCULIDAE						
Coccyzus americanus	5♀ 57.60±0.35 2♂ 62, 63	(6)1.15±0.04	(2)19.95, 20.92	6.33, 6.66	(2)4.54, 4.76	2.14, 2.37
**Piaya cayana* (sea level)	5♀ 116±7.1 8♂ 106.8±2.7	(9)0.57±0.02 P<0.01	(4)13.59±0.36 P<0.01	(7)13.93±0.64	(10)3.26±0.15	(10)1.34±0.03

	Upper extremities: Pectoral and sup. *% body weight*	Upper extremities: Pectoralis *% body weight*	Upper extremities: Supra-coracoideus *% body weight*	"Rest" *% body weight*	Tail *cm.² per gram*	Glide *cm.² per gram*	Buoyancy index
PSITTACIDAE							
**Pyrrhura hoffmanni*	(14)21.36±0.38	(3)18.7±0.25	(3)2.97±0.05	(3)5.69±0.11	(6)0.46±0.04	(6)4.01±0.11	3.71
Brotogeris jugularis	(9)21.82±0.50	(4)19.96±0.35	(4)3.12±0.09	(4)5.43±0.21	(9)0.40±0.02	(9)3.25±0.13	3.20
Bolborhynchus lineola	(2)23.81, 23.85	(2)20.05, 20.07	3.76, 3.78	(1)5.11	(2)0.52, 0.73	(2)3.07, 3.75	3.04
Pionopsitta haematotis	(7)22.10±0.57	(4)19.12±0.88	(4)2.97±0.19	(4)6.57±0.53	(7)0.31±0.02	(7)2.42±0.11	3.23
Pionus senilis	(6)20.82±0.95	(1)19.3, 20.0	(1)2.98, 3.36	(1)9.0, 6.39	(7)0.34±0.04	(8)2.76±0.16	3.49
Amazona autumnalis	(14)18.73±0.36	(4)17.27±0.93	(4)2.38±0.14	(4)7.56±0.31	(13)0.31±0.04	(12)2.20±0.06	3.51
Melopsitticus undulatus	(16)23.91±0.87	(16)20.0±0.70	(6)3.87±0.14	(16)4.98±0.16	(15)0.77±0.04	(16)4.04±0.12	2.84
CUCULIDAE							
Coccyzus americanus	13.57, 14.60	12.41, 13.78	0.82, 1.16	6.32, 6.38	1.87, 2.63	7.00, 7.65	4.22
**Piaya cayana* (sea level)	(9)8.81±0.31 P<0.01	(4)7.56±0.26 P<0.01	(4)0.63±0.05	(4)4.52±0.13 P<0.01	(9)2.61±0.20	(10)6.37±0.32	3.93

(continued)

TABLE 1.—*continued*

	Body weight *grams*	Heart *% body weight*	Upper extremities *% body weight*	Lower extremities *% body weight*	Wings *cm.² per gram*	Aspect ratio
Piaya cayana Chiriqui)	9♀ 108.4±1.8; 11♂ 107±1.6	(14)0.64±0.02	(4)17.77±0.67	(4)15.5±0.79	(6)3.43±0.10	(6)1.36±0.03
Piaya minuta	2♂ 36.62, 37.2	(2)0.72, 0.64	(1)18.98	10.3	(1)4.31	1.35
Crotophaga major	9♀ 140±3.25; P<0.01; 16♂ 157±3.16	(16)0.67±0.02	(7)19.59±0.89	(7)11.27±0.34	(16)3.65±0.08	(16)1.76±0.02
Crotophaga ani (sea level)	15♀ 87.7±0.83; P<0.01; 23♂ 104.37±1.99	(31)0.59±0.02 P<0.01	(5)16.69±0.68 P<0.01	(8)13.05±0.44	(11)3.38±0.14	(10)1.75±0.01
Crotophaga ani (Chiriqui)	6♀ 104.1±7.8; 9♂ 117.1±7.4	(15)0.80±0.02	(9)17.91±0.35	(9)12.7±0.43	(14)2.89±0.07	(15)1.79±0.04
Crotophaga sulcirostris	5♀ 65.1±1.55; P<0.05; 9♂ 72.8±2.14	(9)0.75±0.03	(3)20.39±0.35	(4)13.00±0.57	(9)3.75±1.11	(9)1.67±0.03
Tapera naevia	4♀ 47.49±5.0; 6♂ 55.1±1.00	(7)0.78±0.04	(4)20.65±0.12	(4)10.7±0.89	(5)3.78±0.08	(5)1.73±0.04
Dromococcyx phasianellus	♂ 85.63	0.94	...	6.7	4.84	1.67
TYTONIDAE *Tyto alba*	4♀ 516±10.3; P<0.01; 4♂ 439±15.9	(5)0.72±0.04	(3)19.23±0.72	(4)13.8±1.35	(5)3.17±0.06	(5)2.68±0.07

	Upper extremities: Pectoral and sup. *% body weight*	Upper extremities: Pectoralis *% body weight*	Upper extremities: Supra-coracoideus *% body weight*	"Rest" *% body weight*	Tail *cm.² per gram*	Glide *cm.² per gram*	Buoyancy index
Piaya cayana Chiriqui)	(5)10.31±0.20	(4)9.67±0.15	(4)0.78±0.05	(4)6.57±0.10	(6)2.95±0.26	(6)6.72±0.33	3.98
Piaya minuta	(1)11.99	11.0	0.99	6.99	2.54	7.81	3.77
Crotophaga major	(16)11.25±0.33	(7)11.29±0.35	(7)0.80±0.06	(7)7.50±0.52	(16)2.08±0.06	(16)5.99±0.13	4.40
Crotophaga ani (sea level)	(11)10.44±0.31 P<0.01	(6)9.99±0.17	(6)0.86±0.04	(6)6.15±0.62	(11)1.68±0.13	(11)5.40±0.23	3.90
Crotophaga ani (Chiriqui)	(14)11.72±0.18	(9)10.78±0.19	(9)0.75±0.06	(9)6.36±0.19	(13)1.62±0.08	(13)4.94±0.20	3.72
Crotophaga sulcirostris	(9)12.8±0.19	(3)12.4±0.21	(3)0.92±0.04	(3)7.13±0.11	(9)1.56±0.15	(9)5.67±0.22	3.92
Tapera naevia	(5)12.63±0.58	(4)12.03±0.43	(4)1.02±0.07	(4)7.60±0.42	(5)1.91±0.11	(5)6.17±0.25	3.73
Dromococcyx phasianellus	22.3	...	...	...	1.88	6.94	4.20
TYTONIDAE *Tyto alba*	(5)10.63±0.92	(4)9.79±1.11	(4)0.62±0.05	(3)9.16±1.02	(5)0.33±0.02	(5)3.71±0.11	4.96

	Body weight *grams*	Heart *% body weight*	Upper extremities *% body weight*	Lower extremities *% body weight*	Wings *cm.² per gram*	Aspect ratio
STRIGIDAE *Otus choliba*	3♀ 143±18.8	(5)0.52±0.02	(3)24.34±0.74	(3)10.64±1.35	(4)3.55±0.49	(4)1.88±0.08
**Pulsatrix perspicillata*	2♀ 900, 970 2♂ 710, 800	(4)0.31±0.03	(1)22.0	(2)12.9, 14.3	(4)2.52±0.26	(4)2.08±0.03
Spcotyto cunicularia	5♀ 149±7.4 6♂ 146.7±9.7	(10)0.89±0.01	...	...	(3)3.51±0.34	(3)1.88±0.19
Ciccaba nigrolineata	1♀ 500 1♂ 417	(2)0.50, 0.40	(1)27.19	10.5, 11.42	2.75, 3.44	1.93, 1.96
Ciccaba virgata centralis	1♂ 230	0.46	21.82	9.86	4.05	1.94
Strix varia alleni	2♀ 850, 875 6♂ 718±35.1	(7)0.58±0.04	...	...	(4)2.49±0.2	1.83±0.10
Rhinoptynx clamator	4♀ 425±22.7 (young)	0.50, 0.44	(1)20.55	16.2, 17.59	2.75	2.25
	2♂ 305, 335	0.39,0.42	...	...	...	...
NYCTIBIIDAE **Nyctibius griseus*	13♀ 185±4.6 8♂ 184±10	(19)0.60±0.02	(6)28.06±0.77	(8)2.46±0.04	(14)4.66±0.19	(13)2.47±0.04

	Upper extremities						
	Pectoral and sup. *% body weight*	Pectoralis *% body weight*	Supra-coracoideus *% body weight*	"Rest" *% body weight*	Tail *cm.² per gram*	Glide *cm.² per gram*	Buoyancy index
STRIGIDAE *Otus choliba*	(3)14.27±0.53	(3)13.44±0.66	(3)0.85±0.14	(3)10.07±1.08	(4)0.36±0.10	(4)4.74±0.16	4.36
**Pulsatrix perspicillata*	(3)13.01±0.96	(1)11.3	(1)0.42	(1)10.3	(3)0.27±0.03	2.92±0.30	4.78
Speotyto cunicularia	(3)12.37±0.38	...	...	...	(3)0.59±0.04	(3)4.20±0.27	4.24
Ciccaba nigrolineata	17.3, 15.32	14.75	0.57	11.87	0.45, 0.49	3.48, 4.08	5.08
Ciccaba virgata centralis	12.45	11.8	0.65	9.37	0.54	4.93	5.11
Strix varia alleni	(4)12.8±0.64	...	...	...	0.28±0.05	3.07±0.26	4.72
Rhinoptynx clamator	12.8, 11.50	10.32	1.18	9.05	0.32	3.22	4.58
NYCTIBIIDAE **Nyctibius griseus*	(14)17.07±0.26	(6)15.91±0.53	(6)0.94±0.04	(6)11.11±0.35	(14)1.37±0.04	(14)6.25±0.17	5.19

(continued)

Table 1.—*continued*

	Body weight *grams*	Heart *% body weight*	Upper extremities *% body weight*	Lower extremities *% body weight*	Wings *cm.² per gram*	Aspect ratio
Caprimulgidae						
Chordeiles acutipennis	1♀ 57.2 4♂ 52.40±0.20	(4)1.12±0.06	(4)29.41±0.71	(4)2.73±0.31	(3)5.7±0.52	(3)3.09±0.04
Chordeiles minor chapmani	5♀ 64±4.8 8♂ 60±1.53	(2)1.04, 1.38	...	...	4.96, 5.6	3.26, 3.40
**Nyctidromus albicollis*	15♀ 52.53±0.96 22♂ 53.58±1.11	(27)0.78±0.02	(9)25.60±0.82	(11)5.71±0.19	(19)5.42±0.16	(2)2.20±0.04
Caprimulgus carolinensis	(1)110	(1)0.95	...	...	5.13	2.56
Trochilidae						
Glaucis hirsuta	7♀ 5.53±0.18 P<0.05 5♂ 6.86±0.20	(5)2.54±0.15	(3)32.16±1.73	(5)1.23±0.08	(6)4.43±0.51	(5)2.36±0.17
**Phaethornis guy*	7♀ 5.53±0.25 24♂ 5.99±0.04	7♀ 2.26±0.07 23♂ 2.51±0.06 P<0.01	3♀ 27.52±0.30 5♂ 32.94±1.36 P<0.01	(9)1.13±0.09	(20)4.15±0.09	(21)3.04±0.05
Phaethornis longuemareus	4♀ 2.71±0.03 7♂ 2.52±0.04	3♀ 2.29±0.09 7♂ 2.53±0.10	1♀ 27.11 4♂ 32.05±2.70	(5)1.17±0.16	(8)3.75±0.16	(8)3.11±0.11
Phaeochroa cuvierii	9♀ 8.35±0.25 16♂ 9.19±0.15	4♀ 1.65±0.11 7♂ 1.91±0.08	1♀ 27.09 3♂ 35.99±1.84	(6)2.33±0.14	(7)3.51±0.08	(7)2.95±0.10
Campylopterus hemileucurus	1♀ 9.05, 9.56 13♂ 11.76±0.21	5♀ 1.94±0.04 9♂ 2.08±0.06	1♀ 27.23 4♂ 36.02±0.97	(6)1.64±0.11	(11)3.68±0.10	(10)2.64±0.08

	Upper extremities: Pectoral and sup. *% body weight*	Upper extremities: Pectoralis *% body weight*	Upper extremities: Supra-coracoideus *% body weight*	"Rest" *% body weight*	Tail *cm.² per gram*	Glide *cm.² per gram*	Buoyancy index
Caprimulgidae							
Chordeiles acutipennis	(4)21.50±0.76	(4)19.58±0.78	(4)1.92±0.04	(4)7.91±0.30	(3)1.27±0.25	(3)7.60±0.66	4.83
Chordeiles minor chapmani	(2)19.4, 21.2	...	...	...	0.75, 0.85	6.5, 5.6	4.36
**Nyctidromus albicollis*	(19)17.23±0.25	(10)15.47±0.29	(10)1.80±0.07	(9)8.28±0.05	(20)1.79±0.05	(20)7.54±0.15	4.52
Caprimulgus carolinensis	19.90	...	...	...	1.25	6.24	4.96
Trochilidae							
Glaucis hirsuta	(6)29.88±1.17	(5)19.4±1.09	(5)10.02±0.36	(3)2.88±0.20	(4)2.53±0.20	(6)7.14±0.34	1.31
**Phaethornis guy*	8♀ 27.63±0.09 10♂ 29.11±0.81	3♀ 16.88±0.46 10♂ 19.9±0.07	3♀ 8.27±0.35 10♂ 9.18±0.23	(3)♀ 2.36±0.33 (5) 2.64±0.12	(21)2.57±0.09	(21)7.14±0.19	1.92
Phaethornis longuemareus	3♀ 25.33±0.20 7♂ 30.00±1.57	2♀ 15.60, 15.88 4♂ 18.38±1.82	2♀ 9.31, 9.54 4♂ 10.40±1.24	1♀ 1.92 4♂ 3.27	(8)2.46±0.17	(8)6.84±0.09	2.26
Phaeochroa cuvierii	2♀ 24.08, 25.25 7♂ 33.12±0.88	2♀ 16.08, 16.22 4♂ 20.02±0.97	2♀ 8.00, 9.03 4♂ 12.22±0.51	1♀ 3.01 3♂ 3.67±0.08	(7)1.74±0.17	(7)5.88±0.21	2.72
Campylopterus hemileucurus	2♀ 23.66, 26.80 9♂ 32.28±0.67	1♀ 16.01 5♂ 19.82±0.71	1♀ 7.65 5♂ 12.11±0.35	1♀ 3,51 4♂ 3.85±0.46	(11)2.56±0.13	(11)6.64±0.20	2.83

	Body weight *grams*	Heart *% body weight*	Upper extremities *% body weight*	Lower extremities *% body weight*	Wings *cm.² per gram*	Aspect ratio
Florisuga mellivora	4♀ 7.08±0.19 2♂ 7.82, 7.83	3♀ 1.98±0.09 2♂ 2.33, 2.54	2♀ 25.33, 27.33 2♂ 31.81, 35.04	(4) 1.02±0.02	(4) 3.47±0.18	(4) 3.26±0.13
Colibri thalassinus	1♀ 4.80 3♂ 5.56±0.37	1♀ 1.88 2♂ 2.40, 2.46	...	(1) 1.38	(2) 4.88, 4.90	(2) 2.81, 2.96
Anthracothorax nigricollis	5♀ 6.99±0.22 7♂ 6.84±0.14	4♀ 1.99±0.01 $P<0.01$ 6♂ 2.75±0.10	1♀ 26.73 3♂ 33.52±1.06	(4) 1.25±0.06	(7) 3.61±0.13	(7) 3.08±0.09
Klais guimeti	3♀ 2.55±0.11 1♂ 2.63	3♀ 2.10±0.04 1♂ 2.39	2♀ 24.89, 30.22 1♂ 27.86	(3) 1.33±0.17	(4) 5.16±0.11	(4) 3.06±0.19
Chlorostilbon canivetii	13♀ 3.15±0.07 3♂ 3.08±0.06	12♀ 1.86±0.05 3♂ 2.24±0.08 $P<0.01$	2♀ 27.86, 29.24 2♂ 27.02, 30.33	(4) 1.43±0.25	(5) 3.99±0.26	(5) 3.03±0.18
Thalurania furcata	2♀ 3.86, 4.47	(2) 1.95, 2.33	(1) 24.76	(1) 1.19	(2) 4.12, 4.25	3.01, 3.56
Damophila julie panamensis	8♀ 3.07±0.05 $P<0.01$ 26♂ 3.41±0.04	5♀ 1.88±0.10 11♂ 2.29±0.06 $P<0.01$	2♀ 25.02, 32.86 5♂ 29.52±0.71	(8) 1.42±0.12	(9) 3.71±0.13	(9) 3.07±0.13
Lepidopyga coeruleogularis	3♀ 4.20±0.31	3♀ 1.98±0.20	...	2.13	(3) 3.87±0.18	(3) 2.91±0.14
Amazilia amabilis	8♀ 3.90±0.10 $P<0.01$ 12♂ 4.70±0.10	7♀ 2.03±0.08 5♂ 2.32±0.13	4♀ 27.99±0.79 3♂ 33.30±1.23 $P<0.01$	(7) 1.40±0.12	(8) 4.15±0.13	(8) 3.13±0.13
Amazilia edward	18♀ 4.39±0.05 $P<0.01$ 20♂ 4.90±0.07	13♀ 2.21±0.05 9♂ 2.64±0.10 $P<0.01$	4♀ 28.34±0.45	(7) 1.32±0.10	(17) 3.97±0.11	(17) 2.94±0.05

	Upper extremities: Pectoral and sup. *% body weight*	Upper extremities: Pectoralis *% body weight*	Upper extremities: Supra-coracoideus *% body weight*	"Rest" *% body weight*	Tail *cm.² per gram*	Glide *cm.² per gram*	Buoyancy index
Florisuga mellivora	2♀ 23.47, 24.79 2♂ 29.0, 32.10	2♀ 16.25, 16.30 2♂ 19.1, 21.2	2♀ 7.12, 8.54 2♂ 9.9, 10.9	2♀ 1.86, 2.44 2♂ 2.81, 2.94	(4) 2.44±0.44	(4) 6.57±0.54	2.59
Colibri thalassinus	(2) 26.86, 28.74	...	...	...	(2) 2.58, 2.73	(2) 8.15, 8.19	1.37
Anthracothorax nigricollis	3♀ 24.60±1.99 $P<0.05$ 4♂ 30.51±0.70	2♀ 15.84, 15.92 3♂ 21.5±0.68	2♀ 7.40, 7.63 3♂ 8.56±0.15	1♀ 3.41 3♂ 3.46±0.43	(7) 2.29±0.21	(7) 6.68±0.30	2.65
Klais guimeti	3♀ 23.33±1.35 1♂ 25.20	3♀ 15.4±0.61 1♂ 16.6	3♀ 7.97±0.74 1♂ 8.6	2♀ 3.27, 4.64 1♂ 2.66	(4) 2.44±0.19	(4) 8.71±0.21	2.66
Chlorostilbon canivetii	3♀ 24.77±1.77 2♂ 23.86, 29.07	3♀ 15.89±1.23 2♂ 15.5, 19.1	3♀ 8.88±0.61 2♂ 8.36, 9.97	2♀ 2.02, 2.68 1♂ 3.16	(5) 1.91±0.23	(5) 6.93±0.39	2.37
Thalurania furcata	(2) 21.82, 22.58	(2) 15.2, 16.1	(2) 6.62, 6.48	(1) 2.18	(2) 2.46, 1.81	(2) 6.94, 6.34	2.58
Damophila julie panamensis	4♀ 26.18±2.09 5♂ 26.89±0.74	3♀ 16.19±0.42 4♂ 16.24±1.00	3♀ 10.30±0.51 5♂ 10.30±0.51	1♀ 2.16, 1.79 5♂ 2.63±0.05	(9) 2.21±0.23	(9) 6.84±0.21	2.32
Lepidopyga coeruleogularis	(3) 24.08±1.43	...	...	...	(3) 1.57±0.06	(3) 6.05±0.26	2.50
Amazilia amabilis	4♀ 24.50±0.43 3♂ 30.43±0.45 $P<0.01$	4♀ 16.99±0.57 4♂ 20.3±0.43	4♀ 7.51±0.67 3♂ 10.11±0.67	4♀ 3.48±0.62 3♂ 3.19±0.97	(8) 2.03±0.13	(8) 6.97±0.22	2.63
Amazilia edward	8♀ 26.20±0.41 4♂ 32.54±1.48 $P<0.01$	5♀ 17.35±0.23 1♂ 24.5	5♀ 8.33±0.22 1♂ 9.39	...	(16) 1.98±0.08	(17) 6.58±0.14	2.58

(continued)

TABLE 1.—*continued*

	Body weight *grams*	Heart *% body weight*	Upper extremities *% body weight*	Lower extremities *% body weight*	Wings *cm.² per gram*	Aspect ratio
Amazilia tzacatl	24♀ 4.73±0.06 28♂ 5.29±0.07	14♀ 2.09±0.06 P<0.05 19♂ 2.35±0.07	3♀ 28.98±1.59 4♂ 38.73±2.67	(8)1.66±0.10	(18)4.01±0.09	(18)3.10±0.08
Eupherusa eximia	5♀ 4.25±0.10 7♂ 4.49±0.12	4♀ 2.31±0.06 5♂ 2.43±0.12	5♀ 26.43±0.69	(4)1.51±0.10	(7)4.62±0.10	(7)3.00±0.07
Elvira chionura	10♀ 3.08±0.06 4♂ 3.24±0.14	10♀ 2.07±0.08 4♂ 2.58±0.12 P<0.01	3♀ 26.56±1.02	(4)1.49±0.15	(14)4.55±0.12	(14)3.08±0.09
Lampornis castaneoventris	15♀ 5.14±0.06 P<0.01 21♂ 6.07±0.06	15♀ 2.08±0.06 P<0.01 20♂ 2.33±0.05	3♀ 26.52±1.18 1♂ 37.84, 32.87	(7)2.48±0.23	(33)4.21±0.05	(32)3.04±0.05
Heliodoxa jacula	2♀ 7.39, 8.37 4♂ 9.14±0.22	2♀ 1.98, 2.09 4♂ 2.51±0.17	...	(1)2.37	(5)3.44±0.12	(5)3.39±0.15
Heliothrix barroti	5♀ 5.48±0.20 3♂ 5.46±0.25	4♀ 2.03±0.06 3♂ 2.20±0.11	2♀ 29.24, 30.26	(2)1.03, 1.05	(7)5.07±0.30	(6)3.07±0.10
Philodice bryantae	1♀ 3.31	(1)3.25	(1)29.42	2.06	3.11	3.00
Heliomaster longirostris	1♀ 6.01 2♂ 6.96, 7.20	1♀ 2.68 2♂ 2.11, 2.31	1♀ 36.82	(2)1.46, 1.52	(3)3.23±0.17	(3)3.08±0.19
Archilochus colubris	3♀ 3.36±0.21 3♂ 3.40±0.28	(4)2.30±0.15	...	...	(1)2.51	2.67
Selasphorus scintilla	15♀ 2.24±0.06 P<0.01 12♂ 2.05±0.03	16♀ 2.36±0.07 8♂ 2.74±0.11 P<0.01	1♀ 29.18 5♂ 28.31±0.84	(7)1.18±0.09	(16)2.27±0.14	(16)3.08±0.08

	Upper extremities						
	Pectoral and sup. *% body weight*	Pectoralis *% body weight*	Supra-coracoideus *% body weight*	"Rest" *% body weight*	Tail *cm.² per gram*	Glide *cm.² per gram*	Buoyancy index
Amazilia tzacatl	6♀ 26.04±0.55 P<0.01 10♂ 33.14±1.29	5♀ 17.32±0.92 5♂ 23.46±2.58	5♀ 8.05±0.28 5♂ 10.0±0.37	3♀ 2.93±0.64 4♂ 2.80±0.35	(18)2.11±0.10	(18)6.70±0.16	2.61
Eupherusa eximia	5♀ 21.26±0.96 2♂ 22.90, 25.98	4♀ 13.53±0.99 1♂ 18.1	4♀ 7.35±0.37 1♂ 7.88	(3)2.59±0.30	(7)2.46±0.30	(7)7.58±0.38	2.72
Elvira chionura	9♀ 23.42±0.62 3♂ 27.66±0.84	7♀ 16.25±0.69 1♂ 18.88	7♀ 7.20±0.40 1♂ 7.90	4♀ 2.22±0.21	(13)2.33±0.13	(14)7.39±0.21	2.60
Lampornis castaneoventris	11♀ 24.41±0.31 P<0.01 14♂ 30.98±0.67	4♀ 16.63±0.57 3♂ 21.64±2.20	4♀ 7.69±0.39 3♂ 9.36±0.26	(5)2.62±0.23	(33)2.02±0.05	(33)6.84±0.09	2.69
Heliodoxa jacula	1♀ 26.04 4♂ 31.9±1.14	1♀ 19.8 1♂ 22.9	1♀ 6.24 1♂ 8.90	...	(5)2.23±0.23	(5)6.14±0.25	2.62
Heliothrix barroti	4♀ 26.50±0.50 3♂ 26.47±1.36	3♀ 18.2±0.60 2♂ 16.20, 19.04	3♀ 8.10±0.29 2♂ 7.41, 8.36	(2)2.79, 3.50	(7)2.95±0.24	(7)8.53±0.42	3.09
Philodice bryantae	27.67	18.00	9.67	1.75	1.66	5.68	2.15
Heliomaster longirostris	1♀ 34.46 2♂ 29.18, 35.4	1♀ 25.6 1♂ 25.6	1♀ 8.86 1♂ 9.80	1♀ 2.36	(3)1.71±0.10	(3)5.33±0.11	2.49
Archilochus colubris	(1)25.5	...	...	...	1.58	4.79	2.06
Selasphorus scintilla	6♀ 25.40±0.28 7♂ 29.50±1.44	2♀ 16.8, 19.24 6♂ 17.89±0.56	2♀ 9.23, 8.28 6♂ 9.36±0.41	1♀ 1.66 4♂ 1.84±0.42	(16)2.27±0.14	(16)7.08±0.23	1.87

	Body weight *grams*	Heart *% body weight*	Upper extremities *% body weight*	Lower extremities *% body weight*	Wings *cm.² per gram*	Aspect ratio
TROGONIDAE						
Pharomachrus mocinno	8♀ 206±7.0 9♂ 205±4.5	(14)1.29±0.09	2♀ 31.60, 32.08 2♂ 32.64, 33.64	(5)3.41±0.48	(9)2.40±0.05	(10)1.90±0.03
Trogon massena	11♀ 139±5.19 15♂ 142±4.27	(18)1.24±0.06	6♀ 30.04±2.84	(9)3.21±0.12	(17)2.90±0.16	(17)1.99±0.04
Trogon melanurus	5♂ 118.8±0.25	(6)1.25±0.07	(3)29.65±0.09	(4)3.11±0.17	(6)3.11±0.17	(6)2.05±0.12
Trogon strigilatus	2♀ 63.7, 62.4 1♂ 93.71	(1)1.29	(1)34.26	(1)2.88	(1)3.17	(1)2.00
**Trogon collaris*	18♀ 65.42±0.96 29♂ 63.36±0.66	(40)1.05±0.02	(7)31.15±0.22	(9)2.81±0.10	(23)3.32±0.10	(22)1.92±0.03
Trogon aurantiiventris	1♀ 61.85	1.14	...	2.68	3.59	1.91
Trogon curucui	2♀ 48.3, 57.17 4♂ 51.92±1.96	(6)1.10±0.04	(4)31.16±1.09	(6)2.67±0.13	(6)3.51±0.15	(5)2.07±0.08
Trogon caligatus	5♀ 58.18±3.32 13♂ 56.08±1.63	(16)1.18±0.03	(8)30.54±1.00	(10)2.67±0.13	(13)3.51±0.07	(13)2.01±0.04

	Upper extremities						
	Pectoral and sup. *% body weight*	Pectoralis *% body weight*	Supra-coracoideus *% body weight*	"Rest" *% body weight*	Tail *cm.² per gram*	Glide *cm.² per gram*	Buoyancy index
TROGONIDAE							
Pharomachrus mocinno	5♀ 21.76±0.08 P<0.01 6♂ 22.69±0.18	2♀ 19.2, 20.2 2♂ 20.5, 20.82	2♀ 17.8, 1.90 2♂ 1.88, 2.14	2♀ 10.1, 10.5 2♂ 9.86, 10.68	(9)1.50±0.22	(11)4.21±0.18	3.79
Trogon massena	(17)21.78±0.33	(9)19.57±0.35	(9)1.92±0.09	(6)10.72±0.70	(17)1.59±0.10	(17)4.64±0.20	3.80
Trogon melanurus	(6)20.13±0.43	(3)19.1±0.67	(3)1.65±0.04	(3)8.94±0.29	(6)1.37±0.06	(6)4.30±0.15	3.91
Trogon strigilatus	(1)24.82	(1)22.6	(1)2.22	(1)9.44	(1)2.26	(1)5.76	3.79
**Trogon collaris*	(28)23.37±0.21	(14)20.82±0.31	(14)2.40±0.06	(8)8.87±0.37	(21)1.80±0.07	(22)5.52±0.12	3.69
Trogon aurantiiventris	21.8	...	...	...	1.94	5.94	3.71
Trogon curucui	(6)22.27±0.38	(4)20.09±0.49	(4)2.12±0.17	(4)9.05±0.58	(6)1.99±0.13	(6)6.10±0.42	3.68
Trogon caligatus	(19)22.90±0.42	(9)19.54±0.58	(9)2.23±0.10	(8)8.78±0.29	(12)1.74±0.11	(13)5.71±0.14	3.68

(continued)

TABLE 1.—*continued*

	Body weight *grams*	Heart *% body weight*	Upper extremities *% body weight*	Lower extremities *% body weight*	Wings *cm.² per gram*	Aspect ratio
ALCEDINIDAE						
Megaceryle torquata	5♀ 335±7.4 4♂ 317±5.9	(9)1.02±0.06	(4)26.27±1.02	(5)3.07±0.20	(7)1.97±0.06	(8)2.33±0.04
Megaceryle alcyon	13♀ 148±2.8 11♂ 147±3.4	(12)1.38±0.03	...	(1)2.48	(1)2.49	2.50
**Chloroceryle amazona*	6♀ 131.8±4.48 11♂ 120.9±2.4	(10)1.06±0.03	(5)25.90±1.02	(5)2.99±0.17	(8)2.59±0.06	(8)2.16±0.03
Chloroceryle americana	6♀ 39.81±2.03 14♂ 36.54±0.6	(12)1.23±0.04	(5)24.12±0.78	(6)2.84±0.11	(11)3.36±0.17	(11)2.19±0.06
Chloroceryle aenea	1♀ 15.1 4♂ 15.59±0.49	(5)1.35±0.06	(3)23.27±0.64	(3)2.66±0.32	(3)3.81±0.36	(3)1.94±0.07
MOMOTIDAE						
Momotus momota lessoni	5♀ 130.3±4.0 10♂ 135.0±4.2	(11)0.49±0.02	(5)31.02±0.73	(5)6.23±0.24	(11)2.94±0.07 P<0.01	(11)1.70±0.03
**Momotus momota conexus* (Chagres)	5♀ 102±1.5 11♂ 112±2.0	(10)0.39±0.01	(5)28.69±1.08	(6)6.44±0.30	(10)3.36±0.08	(10)1.74±0.02
BUCCONIDAE						
**Notharchus macrorhynchos*	5♀ 97.0±5.2 12♂ 95.4±2.0	(11)0.45±0.02	(6)28.56±0.66	(6)4.70±0.21	(3)2.68±0.22	(4)2.03±0.35
Malacoptila panamensis	4♀ 43.9±1.30 6♂ 44.1±0.55	(6)0.58±0.02	(4)27.90±0.59	(4)4.21±0.08	(6)3.28±0.04	(5)1.81±0.12

	Upper extremities						
	Pectoral and sup. *% body weight*	Pectoralis *% body weight*	Supra-coracoideus *% body weight*	"Rest" *% body weight*	Tail *cm.² per gram*	Glide *cm.² per gram*	Buoyancy index
ALCEDINIDAE							
Megaceryle torquata	(9)15.41±0.57	(3)14.9±0.41	(4)1.25±0.05	(4)9.43±0.32	(7)0.30±0.01	(7)2.46±0.05	3.68
Megaceryle alcyon	(1)17.40	...	...	...	0.48	3.16	3.63
**Chloroceryle amazona*	(9)16.48±0.43	(5)15.78±0.49	(5)1.56±0.08	(5)8.56±0.72	(8)0.49±0.04	(8)3.38±0.10	3.60
Chloroceryle americana	(11)16.56±0.45	(5)15.42±0.63	(5)1.54±0.11	(5)7.16±0.29	(11)0.72±0.07	(11)4.80±0.33	3.35
Chloroceryle aenea	(4)16.98±0.19	(3)15.22±0.31	(3)1.85±0.10	(3)6.53±0.15	(3)0.69±0.09	(3)5.15±0.26	3.09
MOMOTIDAE							
Momotus momota lessoni	(11)20.48±0.32	(7)19.29±0.32	(7)1.63±0.09	(5)10.07±0.39	(10)1.03±0.03	(10)4.30±0.13	3.85
**Momotus momota conexus* (Chagres)	(9)19.05±0.55	(5)17.73±0.97	(5)1.67±0.07	(5)9.30±0.11	(10)1.19±0.06	(10)4.76±0.11	3.99
BUCCONIDAE							
**Notharchus macrorhynchos*	(10)18.72±0.49	(6)18.02±0.43	(6)1.38±0.07	(6)9.17±0.23	(4)0.45±0.11	(3)3.39±0.29	3.53
Malacoptila panamensis	(6)18.09±0.46	(6)16.9±0.33	(6)1.21±0.04	(4)9.48±0.16	(6)0.84±0.05	(6)4.58±0.11	3.40

	Body weight *grams*	Heart *% body weight*	Upper extremities *% body weight*	Lower extremities *% body weight*	Wings *cm.² per gram*	Aspect ratio
Nonnula frontalis	2♀ 14.5, 15.0 1♂ 15.66	(1)0.76	(1)24.03	3.91	5.11	1.63
CAPITONIDAE **Eubucco bourcierii*	8♀ 32.80±0.50 12♂ 34.00±0.60	(13)0.75±0.02	(6)19.54±0.70	(6)9.4±0.37	(13)3.03±0.14	(13)1.64±0.03
RAMPHASTIDAE **Aulacorhynchus prasinus*	16♀ 149±4.05 15♂ 160±3.49	(26)0.62±0.01	(4)22.19±1.01	(5)11.0±0.23	(15)1.88±0.05	(15)1.69±0.28
Pteroglossus torquatus (sea level)	8♀ 216±9.0 10♂ 236±7	(18)0.68±0.02 P<0.01	(5)21.87±1.07	(6)9.93±0.39	(15)1.91±0.08	(14)1.71±0.02
Pteroglossus frantzii	16♀ 263±4 10♂ 266±5	(14)0.77±0.01	(6)23.29±0.36	(6)10.92±0.29	(11)1.76±0.03	(11)1.69±0.03
Ramphastos swainsonii	6♀ 563±20 2♂ 397, 432	(7)0.79±0.05	(6)23.55±0.77	(6)12.98±0.64	(7)1.80±0.05	(6)1.64±0.03
PICIDAE *Picumnus olivaceus*	5♀ 10.57±0.20 8♂ 10.63±0.18	(9)1.24±0.04	(6)22.36±0.37	(8)8.41±0.33	(9)5.24±0.15	(9)1.62±0.04
Colaptes auratus luteus (Ohio)	9♀ 136±2.32 16♂ 135±2.99	(4)1.19±0.10		6.2, 7.69	2.15, 2.91	1.78, 1.85

	Upper extremities						
	Pectoral and sup. *% body weight*	Pectoralis *% body weight*	Supra-coracoideus *% body weight*	"Rest" *% body weight*	Tail *cm.² per gram*	Glide *cm.² per gram*	Buoyancy index
Nonnula frontalis	16.75	15.6	1.15	7.28	1.34	7.09	3.56
CAPITONIDAE **Eubucco bourcierii*	(13)13.07±0.26	(7)11.8±0.50	(7)1.10±0.03	(6)6.52±0.36	(12)0.49±0.03	(13)3.90±0.18	3.04
RAMPHASTIDAE **Aulacorhynchus prasinus*	(16)14.39±0.29	(4)13.1±0.59	(4)1.25±0.09	(4)7.81±0.46	(16)0.38±0.02	(15)2.49±0.06	3.19
Pteroglossus torquatus (sea level)	(15)13.73±0.30 P<0.01	(5)13.06±0.50	(5)1.14±0.05	(5)7.88±0.52	(15)0.42±0.02	(15)2.56±0.07	3.43
Pteroglossus frantzii	(11)14.75±0.16	(6)13.70±0.14	(6)1.16±0.06	(6)8.43±0.30	(11)0.46±0.03	(11)2.40±0.06	3.34
Ramphastos swainsonii	(7)14.19±0.48	(6)13.12±0.50	(6)1.27±0.06	(6)9.16±0.45	(7)0.42±0.04	(7)2.42±0.08	3.77
PICIDAE *Picumnus olivaceus*	(9)15.91±0.66	(6)14.3±0.55	(6)1.35±0.07	(6)6.75±0.58	(9)0.58±0.03	(9)6.37±0.13	3.39
Colaptes auratus luteus (Ohio)	25.72, 28.90	16.9, 18.7	1.09, 1.44	7.73, 8.76	0.53, 0.68	3.00, 3.99	3.67

(*continued*)

TABLE 1.—*continued*

	Body weight *grams*	Heart *% body weight*	Upper extremities *% body weight*	Lower extremities *% body weight*	Wings *cm.² per gram*	Aspect ratio
Colaptes auratus (Florida)	8♀ 102.8±3.41 5♂ 114±3.08	(10)1.14±0.03	(3)29.62±0.35	(3)7.47±0.15	(8)3.15±0.13	(8)1.87±0.03
Piculus rubiginosus	6♀ 72.42±2.14 7♂ 79.60±1.9	(10)1.32±0.04	(5)26.85±0.87	(6)7.83±0.18	(9)3.18±0.10	(8)1.86±0.04
Dryocopus lineatus	6♀ 175±5 8♂ 185±4	(11)1.06±0.03	(8)27.79±0.58	(8)8.37±0.17	(9)3.04±0.07	(7)1.84±0.02
Melanerpes formicivorus	11♀ 76.1±1.68 13♂ 78.6±1.7	(20)1.12±0.03	(5)24.97±1.30	(6)6.36±0.12	(16)3.70±0.13	(16)2.07±0.08
Melanerpes erythrocephalus	6♀ 65.8±3.98 1♂ 66	(5)1.17±0.11	(1)26.32	(1)6.04	(4)3.84±0.25	(4)1.98±0.06
Centurus carolinus	9♀ 56.24±2.22 22♂ 67.22±1.25	(20)1.18±0.03	(7)28.27±0.31	(8)6.29±0.24	(20)4.05±0.12	(20)1.86±0.02
Centurus rubricapillus	12♀ 49.0±1.11 P<0.01 19♂ 55.9±0.97	(12)1.23±0.03,	(6)27.3±0.90	(7)6.02±0.15	(10)3.74±0.14	(10)1.89±0.04
Centurus pucherani	2♀ 49.87, 51.6 1♂ 58.37±1.82	(8)1.23±0.04	(8)25.85±0.54	(8)7.06±0.16	(8)3.58±0.14	(8)1.99±0.04
Centurus chrysauchen	5♀ 47.0±0.51 P<0.01 4♂ 58.6±2.60	(11)1.24±0.02	24.25	5.45, 6.92	(8)4.08±0.17	(7)1.88±0.05
Sphyrapicus varius	7♀ 46.12±1.80 18♂ 47.2±0.93	(7)1.41±0.05	23.90, 34.22	5.18, 8.45	(4)4.74±0.25	(4)1.97±0.12

	Upper extremities: Pectoral and sup. *% body weight*	Upper extremities: Pectoralis *% body weight*	Upper extremities: Supra-coracoideus *% body weight*	"Rest" *% body weight*	Tail *cm.² per gram*	Glide *cm.² per gram*	Buoyancy index
Colaptes auratus (Florida)	(5)20.01±0.27	(3)19.22±0.02	(3)1.24±0.09	(3)9.16±0.43	(8)0.59±0.05	(8)4.12±0.18	4.25
Piculus rubiginosus	(10)18.51±0.38	(8)17.25±0.44	(8)1.31±0.06	(5)8.67±0.14	(10)0.46±0.03	(9)4.02±0.09	3.67
Dryocopus lineatus	(10)17.98±0.29	(8)16.41±0.28	(8)1.33±0.03	(8)9.55±0.36	(9)0.36±0.02	(9)3.71±0.08	4.22
Melanerpes formicivorus	(17)18.41±0.33	(6)17.03±0.29	(6)1.14±0.07	(5)8.77±0.44	(15)0.53±0.02	(16)4.68±0.13	3.92
Melanerpes erythrocephalus	(4)16.2±0.88	(1)16.9	0.99	8.43	(4)0.55±0.09	(4)4.72±0.33	3.80
Centurus carolinus	(16)17.80±0.55	(8)18.7±0.25	(7)0.98±0.06	(8)8.32±0.16	(19)0.63±0.04	(20)5.11±0.19	3.91
Centurus rubricapillus	(9)19.09±0.45	(7)18.04±0.51	(7)1.13±0.08	(6)8.21±0.29	(10)0.39±0.03	(10)4.50±0.19	3.76
Centurus pucherani	(8)17.90±0.52	(8)16.81±0.49	(8)1.09±0.05	(8)7.95±0.17	(8)0.40±0.04	(8)4.56±0.22	3.69
Centurus chrysauchen	(8)18.77±0.47	16.2	1.03	7.02	(7)0.45±0.03	(7)4.78±0.17	3.91
Sphyrapicus varius	(3)22.74±1.1	(3)21.34±1.02	(3)1.31±0.14	6.76, 10.70	(4)0.76±0.01	(4)6.01±0.27	4.02

	Body weight grams	Heart % body weight	extremities % body weight	extremities % body weight	cm.² per gram	Aspect ratio
Veniliornis fumigatus	4♀ 31.79±1.85; 3♂ 30.28±0.81	(8)1.35±0.05	(2)25.36, 26.49	(4)6.79±0.19	(8)4.48±0.13	(7)1.60±0.05
Dendrocopos villosus	6♀ 42.30±3.16; 3♂ 44.84±1.64	(7)1.22±0.06	(3)29.24±0.70	(4)7.71±0.47	(8)3.96±0.20	(8)1.81±0.03
**Dendrocopos pubescens*	22♀ 27.16±0.43; 25♂ 26.22±0.38	(6)1.34±0.03	(9)25.08±0.54	(9)6.08±0.22	(9)5.25±0.16	(8)1.96±0.03
Dendrocopos borealis	5♀ 44.7±3.0; 7♂ 42.9±2.5	(10)1.31±0.04	...	...	(2)4.18, 4.50	1.87, 1.91
Phloeoceastes guatemalensis	6♀ 233±10; 11♂ 247±5	(10)0.91±0.03	(5)24.42±0.37	(6)11.51±0.62	(9)2.42±0.07	(9)1.74±0.06
Phloeoceastes melanoleucos	4♀ 225±7; 2♂ 215, 248	(6)0.87±0.05	(6)23.83±0.56	(6)11.36±0.21	(6)2.61±0.10	(6)1.79±0.04
DENDROCOLAPTIDAE						
Dendrocincla fuliginosa	4♀ 41.73±1.94; 1♂ 43.0	(3)1.09±0.09	(2)24.95, 27.40	(3)7.65±0.68	(3)4.81±0.39	(3)1.69±0.09
Dendrocincla homochroa	4♀ 36.8±0.32; 6♂ 45.3±1.07	(6)1.53±0.06	(2)29.45, 31.86	(2)7.9, 7.45	(4)4.32±0.24	(3)1.67±0.12
**Sittasomus griseicapillus*	11♀ 12.89±0.22; P<0.01; 21♂ 14.32±0.13	7♀ 1.10±0.04; P<0.01; 13♂ 1.29±0.06	4♀ 23.82±0.94; 6♂ 31.68±1.40	(11)6.57±0.33	(22)6.91±0.13	(20)1.72±0.03
Glyphorynchus spirurus	3♀ 12.53±0.92; 7♂ 13.90±0.78	(9)1.45±0.11	2♀ 19.54, 21.11; 6♂ 24.85±0.40	(8)7.56±0.21	(9)5.81±0.23	(8)1.78±0.05

	Upper extremities: Pectoral and sup. % body weight	Upper extremities: Pectoralis % body weight	Upper extremities: Supra-coracoideus % body weight	"Rest" % body weight	Tail cm.² per gram	Glide cm.² per gram	Buoyancy index
Veniliornis fumigatus	(8)17.42±0.52	(5)15.22±0.49	(5)1.38±0.05	7.89, 8.70	(8)0.65±0.03	(8)5.57±0.15	3.78
Dendrocopos villosus	(7)19.19±0.75	(4)18.37±0.49	(4)1.63±0.09	(4)8.56±0.44	(7)0.66±0.09	(8)4.96±0.21	3.80
**Dendrocopos pubescens*	(9)18.04±0.41	(9)16.69±0.36	(9)1.35±0.05	(9)7.00±0.59	(8)1.19±0.06	(9)7.03±0.20	3.97
Dendrocopos borealis	(2)15.6, 16.12	...	...	...	(2)0.79, 0.87	(2)5.50, 5.83	3.90
Phloeoceastes guatemalensis	(9)15.53±0.23	(5)14.8±0.20	(5)1.13±0.08	(5)8.49±0.36	(9)0.25±0.01	(9)2.92±0.11	3.90
Phloeoceastes melanoleucos	(6)15.32±0.41	(6)14.20±0.44	(6)1.15±0.08	(6)8.48±0.14	(6)0.27±0.02	(6)3.12±0.13	4.16
DENDROCOLAPTIDAE							
Dendrocincla fuliginosa	3♀ 20.25±3.0; 1♂ 27.40	15.15, 17.34	1.54, 1.73	8.07, 8.52	(3)1.22±0.09	(3)6.36±0.46	4.09
Dendrocincla homochroa	(4)20.62±0.97	(3)19.23±1.1	(3)1.87±0.11	(3)8.68±0.34	(4)0.87±0.12	(4)5.65±0.25	3.83
**Sittasomus griscicapillus*	(8)16.90±0.38; (12)22.13±0.74	5♀ 15.54±0.51; 9♂ 20.91±0.55	5♀ 1.71±0.07; 9♂ 2.11±0.05	4♀ 6.52±0.59; 6♂ 8.51±0.59	(20)2.06±0.08	(20)9.64±0.15	4.13
Glyphorynchus spirurus	2♀ 14.98, 16.80; 7♂ 18.35±0.44	2♀ 13.7, 15.30; 6♂ 16.35±0.36	2♀ 1.28, 1.50; 6♂ 1.76±0.14	2♀ 4.56, 4.31; 6♂ 6.73±0.15	(7)1.56±0.17	(8)7.96±0.38	3.74

(continued)

TABLE 1.—*continued*

	Body weight *grams*	Heart *% body weight*	Upper extremities *% body weight*	Lower extremities *% body weight*	Wings *cm.² per gram*	Aspect ratio
Dendrocolaptes certhia	2♂ 67.10, 69.07	(2)0.62, 0.66	(2)23.63, 26.21	8.71, 9.30	4.29	1.66, 1.70
Xiphorhynchus guttatus	10♀ 44.85±0.42 P<0.01 9♂ 48.16±0.99	(12)0.78±0.02	3♀ 24.17±0.33 ♂ 27.32	(5)8.19±0.33	(11)4.29±0.15	(11)1.68±0.02
Xiphorhynchus erythropygius	8♀ 45.57±0.56 7♂ 49.0±0.70	(11)1.00±0.04	3♀ 23.88±1.10 5♂ 31.17±2.53	(8)7.37±0.42	(9)4.46±0.11	(8)1.76±0.03
Lepidocolaptes affinis	20♀ 34.6±0.50 16♂ 35.36±0.58	(35)0.90±0.02	3♀ 25.99±1.08 3♂ 29.8±1.78	(7)8.41±0.40	(27)5.38±0.09	(30)1.73±0.02
Campylorhamphus pusillus	1♀ 45.33 1♂ 39.0	(2)0.78, 0.97	...	...	(2)3.33, 4.34	1.66, 1.62
FURNARIIDAE						
Synallaxis albescens	2♀ 13.24, 15.53 6♂ 13.50±0.21	(8)1.07±0.04	1♀ 16.30 4♂ 19.55±0.69	(6)11.08±0.50	(7)4.01±0.13	(5)1.53±0.01
Synallaxis brachyura	1♀ 16.89 5♂ 18.84±0.96	(7)1.00±0.07	(3)18.49±0.89	(4)12.77±0.77	(5)3.65±0.13	(4)1.54±0.04
Cranioleuca erythrops	6♀ 16.78±0.62 12♂ 17.04±0.26	(4)♀ 1.05±0.02 P<0.01 7♂ 1.26±0.08	(8)19.77±0.69	(10)10.33±0.47	(17)5.01±0.09	(18)1.58±0.03
Margarornis rubiginosus	2♂ 16.1, 19.53	(2)0.97, 1.83	...	...	5.68	1.73
Premnoplex brunnescens	3♀ 15.68±0.50 5♂ 15.81±0.41	(8)1.00±0.03	20.64	(3)9.82±0.27	(6)4.56±0.13	(6)1.53±0.06

	Upper extremities						
	Pectoral and sup. *% body weight*	Pectoralis *% body weight*	Supra-coracoideus *% body weight*	"Rest" *% body weight*	Tail *cm.² per gram*	Glide *cm.² per gram*	Buoyancy index
Dendrocolaptes certhia	(2)16.30, 18.02	14.81, 16.3	1.49, 1.72	7.33, 8.19	0.97, 1.14	4.08, 5.61	4.19
Xiphorhynchus guttatus	6♀ 16.91±0.36 P<0.01 5♂ 21.18±1.01	3♀ 15.83±0.20 1♂ 17.0	3♀ 1.72±0.07 1♂ 1.81	3♀ 6.62±0.41 1♂ 8.51	(11)1.12±0.04	(11)5.73±0.06	3.92
Xiphorhynchus erythropygius	4♀ 17.13±0.74 5♂ 23.59±1.81	(9)18.95±1.47	4♀ 1.60±0.05 5♂ 1.89±0.05	3♀ 7.32±0.53 5♂ 9.58±0.59	(9)1.24±0.06	(9)6.39±0.28	3.88
Lepidocolaptes affinis	14♀ 17.33±0.28 P<0.01 13♂ 18.86±0.35	5♀ 17.0±0.65 4♂ 18.22±0.93	5♀ 1.58±0.05 4♂ 1.70±0.15	3♀ 7.82±0.57 3♂ 9.08±0.62	(26)1.58±0.06	(30)7.46±0.13	4.20
Campylorhamphus pusillus	16.63, 17.43	15.2, 16.0	1.43, 1.43	...	1.03, 1.46	4.77, 6.28	3.65
FURNARIIDAE							
Synallaxis albescens	2♀ 11.82, 14.40 5♂ 13.78±0.35	1♀ 10.4 5♂ 12.18±0.32	1♀ 1.42 6♂ 1.57±0.08	2♀ 4.48, 4.61 4♂ 5.83±0.24	(6)1.62±0.11	(5)6.51±0.20	2.98
Synallaxis brachyura	(6)12.98±0.54	(4)11.06±0.44	(4)1.54±0.08	(3)6.15±0.28	(5)1.43±0.08	(5)5.51±0.17	3.33
Cranioleuca erythrops	(18)13.75±0.30	(12)12.91±0.45	(12)1.20±0.03	(8)6.18±0.21	(18)1.61±0.08	(18)7.18±0.13	3.59
Margarornis rubiginosus	18.3	...	...	...	1.68	7.38	3.92
Premnoplex brunnescens	(6)14.14±0.29	(4)12.46±0.41	(4)1.52±0.11	5.74	(5)1.36±0.14	(6)6.22±0.19	3.37

	Body weight *grams*	Heart *% body weight*	Upper extremities *% body weight*	Lower extremities *% body weight*	Wings *cm.² per gram*	Aspect ratio
Pseudocolaptes lawrencii	3♀ 50.94±0.19 2♂ 52.55, 55.0	(5)1.16±0.22	...	12.7	(3)3.55±0.18	(3)1.73±0.06
Syndactyla subalaris	2♀ 33.41, 32.50 3♂ 34.60±0.37	(5)1.17±0.06	(2)27.12, 28.10	(3)10.48±0.21	(5)4.33±0.08	(6)1.59±0.05
**Anabacerthia striaticollis*	5♀ 20.57±0.44 11♂ 22.62±0.25	4♀ 1.19±0.04 P<0.05 9♂ 1.49±0.11	(4)29.98±1.49	(8)7.99±0.19	(15)5.82±0.08	(15)1.66±0.02
Automolus ochrolaemus	1♀ 42.10 5♂ 40.05±1.00	(4)1.48±0.09	27.46	(4)8.83±0.19	(5)3.46±0.06	(5)1.53±0.03
Thripadectes rufobrunneus	2♀ 52.63, 64.8 2♂ 56.02, 51.5	(4)1.01±0.10	...	12.1	(4)3.02±0.13	(4)1.48±0.05
Xenops rutilans	5♀ 11.95±0.28 7♂ 12.40±0.19	(10)1.35±0.05	(1)20.57	5.95, 8.18	(11)6.11±0.11	(11)1.74±0.02
Sclerurus guatamalensis	1♀ 36.48 1♂ 37.65	(2)1.27, 1.32	(1)28.59	(1)9.98	(2)4.09, 4.50	1.57, 1.60
FORMICARIIDAE						
**Cymbilaimus lineatus*	2♀ 38.65, 40.53 6♂ 32.92±1.19	(6)0.55±0.02	(5)17.46±0.51	(5)10.98±0.55	(6)2.94±0.19	(6)1.45±0.05
Taraba major	5♀ 68.0±2.26 5♂ 67.15±0.74	(10)0.61±0.03	(5)17.26±0.50	(5)13.42±0.89	(5)2.60±0.10	(5)1.45±0.05
Thamnophilus doliatus	11♀ 28.10±0.31 13♂ 28.0±0.40	(12)0.70±0.03	(5)16.13±0.55	(7)10.8±0.45	(7)3.92±0.18	(7)1.48±0.04

	Upper extremities						
	Pectoral and sup. *% body weight*	Pectoralis *% body weight*	Supra-coracoideus *% body weight*	"Rest" *% body weight*	Tail *cm.² per gram*	Glide *cm.² per gram*	Buoyancy index
Pseudocolaptes lawrencii	(3)13.1±0.39	...	...	...	(3)1.07±0.07	(13)4.92±0.23	3.63
Syndactyla subalaris	(5)15.82±0.80	(5)15.11±0.91	(5)1.61±0.06	(2)7.63, 8.60	(5)1.36±0.10	(6)6.24±0.14	3.74
**Anabacerthia striaticollis*	4♀ 16.49±0.66 10♂ 20.36±0.82	3♀ 14.94±1.00 6♂ 19.49±1.08	3♀ 1.53±0.07 6♂ 1.75±0.07	(4)8.42±0.66	(14)1.47±0.04	(15)7.79±0.30	4.00
Automolus ochrolaemus	(6)18.60±0.72	(3)17.8±0.60	(3)1.68±0.24	7.71	(6)0.89±0.07	(5)4.73±0.08	3.44
Thripadectes rufobrunneus	(4)13.07±0.75	(2)12.52, 9.94	1.28, 1.36	...	(4)0.84±0.11	(4)4.29±0.13	3.40
Xenops rutilans	(10)16.13±0.51	(3)13.79±0.15	(3)0.88±0.24	6.28	(10)1.45±0.07	(11)8.08±0.18	3.73
Sclerurus guatamalensis	(2)21.38, 21.29	19.20, 19.25	2.04, 2.18	(1)7.30	0.72, 0.82	5.15, 5.82	3.78
FORMICARIIDAE							
**Cymbilaimus lineatus*	(6)11.59±0.39	(4)10.76±0.41	(4)1.19±0.12	(5)5.76±0.24	(6)0.79±0.11	(6)4.23±0.33	3.15
Taraba major	(6)11.12±0.27	(5)10.14±0.28	(5)1.12±0.05	(5)6.00±0.31	(5)0.53±0.06	(5)3.51±0.12	3.18
Thamnophilus doliatus	(7)11.50±0.19	(5)10.55±0.16	(5)1.15±0.07	(5)4.43±0.63	(7)0.76±0.05	(7)5.19±0.25	3.44

(continued)

TABLE 1.—*continued*

	Body weight *grams*	Heart *% body weight*	Upper extremities *% body weight*	Lower extremities *% body weight*	Wings *cm.² per gram*	Aspect ratio
Thamnophilus punctatus	2♀ 21.7, 24.95 4♂ 21.11±1.41	(8)0.79±0.03	(3)19.51±1.46	(6)8.63±0.34	(7)4.20±0.15	(8)1.45±0.04
Thamnistes anabatinus	2♀ 22.87, 23.58 2♂ 19.25, 19.67	(4)0.93±0.09	...	...	(4)4.35±0.26	(4)1.55±0.06
Dysithamnus mentalis	12♀ 14.55±0.28 18♂ 14.21±0.19	9♀ 1.10±0.05 9♂ 1.23±0.05	3♀ 19.37±0.81 5♂ 20.97±0.62	(10)8.77±0.36	(17)5.19±0.08	(16)1.51±0.02
Myrmotherula surinamensis	6♀ 9.60±0.11 4♂ 9.88±0.20	(7)0.99±0.03	(3)16.86±0.15	(4)8.69±0.61	(7)6.09±0.31	(7)1.48±0.02
Myrmotherula schisticolor	8♀ 9.57±0.22 8♂ 9.56±0.16	(11)1.26±0.05	(3)23.15±1.10	(6)8.07±0.29	(11)6.37±0.19	(11)1.50±0.04
Cercomacra tyrannina	8♀ 15.94±0.27 9♂ 16.58±0.36	(10)0.92±0.04	3♀ 14.80±1.34 5♂ 17.56±0.18	(7)11.12±0.30	(10)4.82±0.11	(11)1.42±0.03
Cercomacra nigricans	4♀ 15.6±0.20 7♂ 17.61±0.41	(10)0.84±0.05	(4)15.43±0.60	(4)10.13±0.47	(5)4.40±0.24	(4)1.36±0.12
Myrmeciza longipes	4♀ 28.23±0.72 5♂ 30.37±0.53	(7)0.63±0.03	3♀ 17.89±0.69 2♂ 18.86, 19.37	(6)12.70±0.44	(6)3.14±0.13	(6)1.42±0.06
Myrmeciza exsul	1♀ 28.80	(1)0.66	(1)19.60	14.01	2.64	1.25
Formicarius analis	4♀ 60.83±0.90 3♂ 61.92±1.63	(7)0.86±0.05	(6)30.68±0.98	(3)9.30±0.27	(6)2.92±0.12	(6)1.59±0.04

	Upper extremities: Pectoral and sup. *% body weight*	Upper extremities: Pectoralis *% body weight*	Upper extremities: Supra-coracoideus *% body weight*	"Rest" *% body weight*	Tail *cm.² per gram*	Glide *cm.² per gram*	Buoyancy index
Thamnophilus punctatus	(7)14.36±0.54	(3)12.3±0.82	(3)1.42±0.04	(3)5.79±0.66	(7)0.96±0.10	(7)6.99±0.57	3.40
Thamnistes anabatinus	(4)12.29±0.60	12.1	1.47	...	(4)0.89±0.05	(4)5.68±0.31	3.46
Dysithamnus mentalis	7♀ 13.50±0.33 10♂ 14.64±0.40	5♀ 13.9±0.90 5♂ 13.46±0.51	5♀ 1.32±0.14 7♂ 1.54±0.07	3♀ 5.68±0.68 5♂ 5.93±0.15	(17)0.73±0.05	(17)6.44±0.10	3.53
Myrmotherula surinamensis	(7)11.77±0.21	(3)10.31±0.48	(3)1.33±0.09	(3)5.25±0.19	(7)0.58±0.04	(7)7.19±0.35	3.62
Myrmotherula schisticolor	(11)15.72±0.56	(8)14.31±0.67	(8)1.51±0.07	(4)6.25±0.44	(11)0.99±0.05	(11)7.99±0.23	3.75
Cercomacra tyrannina	5♀ 11.33±0.63 5♂ 12.36±0.20	4♀ 9.85±0.71 5♂ 10.99±0.24	4♀ 1.22±0.04 5♂ 1.16±0.10	3♀ 4.25±0.68 5♂ 5.41±0.12	(10)1.15±0.04	(11)6.52±0.10	3.48
Cercomacra nigricans	(4)10.21±0.50	(4)9.20±0.55	(4)0.97±0.07	(4)5.22±0.46	(4)0.82±0.16	(5)6.23±0.16	3.23
Myrmeciza longipes	(6)12.72±0.27	(6)11.1±0.20	(6)1.59±0.03	(6)5.93±0.26	(6)0.70±0.07	(6)4.23±0.18	3.16
Myrmeciza exsul	13.14	11.68	1.46	6.46	0.31	3.54	2.85
Formicarius analis	(7)22.86±0.53	(7)20.14±0.48	(7)2.72±0.07	(3)7.37±0.28	(7)0.35±0.03	(7)3.50±0.16	3.39

	Body weight *grams*	Heart *% body weight*	extremities *% body weight*	extremities *% body weight*	*cm.² per gram*	Aspect ratio
Gymnopithys bicolor	6♀ 29.58±1.03 5♂ 29.57±0.38	(10)1.01±0.05	(6)29.57±0.38	(8)13.22±0.56	(9)3.56±0.12	(8)1.46±0.04
Hylophylax naevioides	1♀ 16.5 1♂ 16.5	(2)0.72, 0.85	...	(2)10.42, 13.10	4.85, 5.36	1.54, 1.56
PIPRIDAE *Pipra mentalis*	1♀ 16.11 6♂ 14.70±0.47	(7)1.03±0.05	1♀ 26.48 4♂ 29.50±1.01	1♀ 4.84 4♂ 5.99±0.14	(5)4.30±0.30	(4)1.66±0.02
Chiroxiphia lanceolata	4♀ 20.30±1.04	(4)1.11±0.07	(3)29.27±2.68	(4)6.49±0.30	(4)5.46±0.34	(4)1.61±0.05
Corapipo leucorrhea	3♀ 13.26±0.75 P<0.01 10♂ 11.05±0.18	(13)1.51±0.06	22.84, 26.20	(4)5.24±0.58	(9)5.69±0.13	(9)1.59±0.03
**Manacus vitellinus*	16♀ 17.08±0.05 P<0.01 17♂ 19.29±0.05	(22)1.08±0.04	4♀ 21.22±0.55 P<0.01 4♂ 26.89±0.40	4♀ 8.42±0.37 4♂ 11.91±0.73	(13)2.91±0.09	(10)1.61±0.02
Schiffornis turdinus	2♂ 34.1, 36.1	(2)1.49, 1.52	(1)29.94	7.42	4.14	1.82
COTINGIDAE *Cotinga ridgwayi*	6♀ 61.04±2.2 16♂ 53.55±0.90	(16)1.19±0.03	(6)33.04±0.45	(9)6.36±0.20	(13)3.18±0.07	(14)1.94±0.02
Attila spadiceus	1♀ 37.7 7♂ 43.01±1.3	(10)1.40±0.08	(6)25.77±0.93	(8)7.80±0.18	(10)3.65±0.10	(9)1.68±0.02

	Upper extremities						
	Pectoral and sup. *% body weight*	Pectoralis *% body weight*	Supra-coracoideus *% body weight*	"Rest" *% body weight*	Tail *cm.² per gram*	Glide *cm.² per gram*	Buoyancy index
Gymnopithys bicolor	(10)13.69±0.68	(8)11.93±0.70	(8)1.38±0.16	(6)6.46±0.45	(8)0.58±0.03	(8)4.56±0.16	3.35
Hylophylax naevioides	(2)12.98, 13.70	...	...	...	(2)0.65, 0.73	(2)5.88, 6.42	3.62
PIPRIDAE *Pipra mentalis*	1♀ 19.90 6♂ 19.88±1.26	1♀ 16.94 4♂ 18.79±0.80	1♀ 2.96 4♂ 4.72±0.11	1♀ 6.58 4♂ 8.00±0.17	(5)0.62±0.03	(5)5.42±0.34	3.26
Chiroxiphia lanceolata	(3)18.41±0.71	(3)16.98±0.36	(3)1.76±0.07	7.52±0.34	4)0.56±0.02	(4)6.48±0.38	3.85
Corapipo leucorrhea	(13)19.18±0.20	16.9, 18.2	1.69, 1.91	4.25, 6.1	(9)0.79±0.03	(9)7.01±0.14	3.58
**Manacus vitellinus*	5♀ 16.42±0.40 P<0.01 8♂ 19.27±0.31	4♀ 13.88±0.52 4♂ 15.79±0.51	4♀ 2.58±0.09 4♂ 3.82±0.26	4♀ 4.76±0.54 4♂ 7.28±0.55	(13)0.45±0.03	(13)3.81±0.10	2.76
Schiffornis turdinus	(1)21.35	19.19	2.16	8.59	0.87	5.43	3.69
COTINGIDAE *Cotinga ridgwayi*	(15)25.20±0.26	(7)22.60±0.43	(7)2.51±0.12	(6)8.12±0.57	(15)0.69±0.03	(14)4.17±0.11	3.50
Attila spadiceus	(10)18.59±0.34	(9)16.66±0.29	(9)1.83±0.06	(6)7.20±0.51	(10)0.93±0.04	(10)4.96±0.19	3.76

(continued)

TABLE 1.—*continued*

	Body weight *grams*	Heart *% body weight*	Upper extremities *% body weight*	Lower extremities *% body weight*	Wings *cm.² per gram*	Aspect ratio
Rhytipterna holerythra	9♀ 36.25±0.61 9♂ 37.27±0.82	(15)1.41±0.06	4♀ 27.43±0.67 4♂ 30.23±1.32	(11)6.95±0.18	(16)5.21±0.08	(15)1.68±0.02
Lipaugus unirufus	1♀ 80.34	1.06	...	...	3.43	1.89
Pachyramphus versicolor	1♂ 14.86	1.68	...	7.00	4.82	1.65
Pachyramphus cinnamomeus	1♀ 21 2♂ 19.5, 20.2	(3)1.20±0.22	...	5.65, 7.43	5.19, 5.74	1.80, 1.84
Pachyramphus polychopterus	2♀ 20.52, 20.8 3♂ 18.79±0.54	(4)1.16±0.03	(2)22.44, 21.78	(3)8.18±0.94	(3)4.53±0.46	(3)1.73±0.06
**Tityra semifasciata*	10♀ 79.53±2.14 15♂ 79.17±1.12	(18)1.24±0.03	(7)25.98±0.48	(9)9.23±0.78	(16)3.02±0.06	(16)1.89±0.08
Erator inquisitor	1♀ 40.2 3♂ 42.0±3.0	(4)1.23±0.08	(3)25.05±1.25	(3)5.79±0.18	(4)4.49±0.20	(3)2.00±0.08
Querula purpurata	4♀ 100.1±2.98 4♂ 106.76±1.28	(8)1.05±0.04	(7)25.98±0.38	(7)5.00±0.13	(8)5.33±0.18	(8)1.66±0.03
TYRRANIDAE *Sayornis nigricans*	2♀ 20.46, 16.85 3♂ 20.05±0.76	(5)1.18±0.06	(1)32.93	4.27	(5)6.69±0.50	(5)1.79±0.05
Fluvicola pica	3♀ 10.8±0.27 P<0.01 4♂ 12.20±0.24	(3)1.26±0.07	(3)22.31±0.16	(3)7.35±0.36	(3)6.21±0.56	(3)1.64±0.13

	Upper extremities: Pectoral and sup. *% body weight*	Upper extremities: Pectoralis *% body weight*	Upper extremities: Supra-coracoideus *% body weight*	"Rest" *% body weight*	Tail *cm.² per gram*	Glide *cm.² per gram*	Buoyancy index
Rhytipterna holerythra	7♀ 19.41±0.21 7♂ 21.28±0.77	6♀ 17.82±0.46 4♂ 19.84±1.10	6♀ 1.71±0.10 4♂ 1.93±0.14	4♀ 8.11±0.45 4♂ 8.47±0.42	(16)1.55±0.05	(15)7.42±0.13	3.28
Lipaugus unirufus	21.14	19.1	2.04		1.08	1.89	3.86
Pachyramphus versicolor	16.00	...	...	...	1.06	6.39	3.47
Pachyramphus cinnamomeus	(3)16.56±2.01	...	...	...	1.24, 1.27	6.90, 7.52	3.87
Pachyramphus polychopterus	(3)16.85±0.84	(2)15.6, 14.25	(1)1.57, 1.73	(1)5.27, 5.85	(3)1.10±0.24	(3)6.17±0.78	3.31
**Tityra semifasciata*	(16)18.44±0.30	(7)17.35±0.36	(7)1.55±0.04	(7)7.56±0.25	(17)0.51±0.07	(17)3.79±0.24	3.60
Erator inquisitor	(4)17.52±0.51	(4)16.23±0.51	(4)1.55±0.02	(3)7.45±0.55	(4)0.76±0.06	(4)5.69±0.22	3.95
Querula purpurata	(7)17.06±0.26	(7)15.82±0.29	(7)1.25±0.04	(8)8.98±0.29	(7)0.97±0.06	(7)6.47±0.12	4.83
TYRRANIDAE *Sayornis nigricans*	(5)22.86±0.51	(3)20.5±1.0	(3)2.10±0.13	(1)8.92	(5)1.77±0.14	(5)8.96±0.49	4.19
Fluvicola pica	(3)16.00±0.21	(3)14.3±0.21	(3)1.70±0.17	(3)6.30±0.18	(3)1.11±0.11	(3)8.21±0.67	3.75

	Body weight grams	Heart % body weight	extremities % body weight	extremities % body weight	cm.² per gram	Aspect ratio
Muscivora tyrannus	5♀ 27.08±0.59; 4♂ 28.88±0.90	(7)1.48±0.10	(3)33.88±2.75	(4)3.16±0.27	(7)5.42±0.20	(7)1.94±0.07
Tyrannus tyrannus	5♀ 38.8±0.16; 5♂ 37.1±1.51	(5)1.28±0.07	...	...	(8)5.22±0.25	(8)2.05±0.04
Tyrannus melancholicus	7♀ 40.73±0.85; 8♂ 38.98±1.33	(9)1.11±0.04	(6)32.72±0.68	(7)3.42±0.24	(9)4.79±0.21	(9)1.85±0.03
Legatus leucophaius	1♀ 25.64; 3♂ 26.19±0.54	(4)1.71±0.17	(1)30.56	(3)4.29±0.46	(3)4.49±0.12	(3)1.95±0.09
**Myiodynastes maculatus*	11♀ 47.19±0.59; 12♂ 45.1±0.08	(12)1.03±0.04	(6)33.66±1.19	(7)4.49±0.21	(11)4.43±0.10	(11)1.81±0.04
Myiodynastes hemichrysus	1♂ 43.4	(1)0.92	...	...	4.69	1.78
Megarynchus pitangua	2♀ 71.83, 78.2; 4♂ 70.85±2.32	(5)1.23±0.14	(4)33.14±1.53	(5)3.86±0.01	(5)3.25±0.32	(5)1.70±0.03
Myiozetetes cayanensis	8♀ 25.33, 0.77; 6♂ 28.7±1.33	(8)0.88±0.03	(3)27.25±1.09	(4)4.56±0.56	(4)4.94±0.36	(4)1.66±0.07
Myiozetetes similis	4♀ 29.7±4.0; 4♂ 29.60±4.18	(7)0.89±0.05	(3)31.55±2.12	(4)3.97±0.34	(7)5.51±0.20	(6)1.77±0.03
Myiozetetes granadensis	5♀ 29.44±2.35; 3♂ 27.6±1.69	(5)1.02±0.03	28.19, 39.83	(3)3.63±0.18	(5)5.11±0.26	(5)1.77±0.07
Myiarchus crinitus	2♀ 31.6, 32.2; 3♂ 36.3±0.91	(6)1.10±0.04	...	...	(5)5.00±0.23	1.74±0.07

	Upper extremities						
	Pectoral and sup. % body weight	Pectoralis % body weight	Supra-coracoideus % body weight	"Rest" % body weight	Tail cm.² per gram	Glide cm.² per gram	Buoyancy index
Muscivora tyrannus	3♀ 23.8±1.77; 3♂ 27.52±1.13	2♀ 20.1, 24.7; 2♂ 23.6, 26.6	2♀ 1.97, 2.21; 2♂ 2.29, 2.47	(3)8.12±0.49	(7)2.11±0.18	(7)8.03±0.10	4.06
Tyrannus tyrannus	(5)21.6±1.2	...	...	...	(8)1.15±0.11	7.06±0.30	4.71
Tyrannus melancholicus	(8)24.43±0.58	(7)22.27±0.68	(7)2.25±0.09	(6)8.83±0.27	(7)1.34±0.05	(8)6.79±0.19	4.04
Legatus leucophaius	(4)22.09±0.41	(2)20.8, 20.5	1.86, 2.21	(1)7.85	(3)1.07±0.14	(3)6.19±0.28	3.64
**Myiodynastes maculatus*	(11)24.65±0.59	(6)22.64±0.81	(6)2.26±0.09	(6)8.76±0.41	(11)1.20±0.07	(11)6.05±0.14	3.96
Myiodynastes hemichrysus	(1)23.53	21.39	2.14	...	1.15	8.09	4.04
Megarynchus pitangua	(5)24.04±1.10	(4)22.17±1.43	(4)2.23±0.21	(4)8.73±0.30	(5)0.87±0.06	(5)4.65±0.40	3.67
Myiozetetes cayanensis	(4)22.39±2.40	(3)20.15±3.36	(3)2.23±0.26	(3)7.87±1.69	(4)1.44±0.17	(4)8.08±0.47	3.84
Myiozetetes similis	(5)23.35±1.42	(5)21.65±1.02	(5)2.36±0.12	(3)7.46±0.42	(7)1.45±0.15	(7)7.51±0.17	4.27
Myiozetetes granadensis	(4)22.08±0.88	(3)19.9±1.13	(4)2.26±0.35	8.06, 9.25	(5)1.28±0.09	(5)7.63±0.49	3.96
Myiarchus crinitus	(5)19.94±1.23				(5)1.46±0.12	7.01±0.20	4.04

(continued)

TABLE 1.—*continued*

	Body weight *grams*	Heart *% body weight*	Upper extremities *% body weight*	Lower extremities *% body weight*	Wings *cm.² per gram*	Aspect ratio
Myiarchus ferox	6♀ 30.3±0.90 6♂ 32.1±0.98	(7)0.91±0.03	(4)29.52±1.61	(5)6.42±0.47	(5)5.35±0.19	(6)1.70±0.04
Myiarchus tuberculifer	11♀ 19.28±0.39 14♂ 20.44±0.38	(16)0.85±0.03	(4)29.54±1.63	(5)5.52±0.48	(15)5.86±0.11	(14)1.63±0.02
Nuttallornis borealis	1♂ 33.3	(1)1.26	24.98	3.94	4.47	1.74
Contopus virens	2♀ 13.35, 15.50 10♂ 14.03±0.31	(3)1.35±0.13	23.70, 27.94	3.02, 3.36	6.29, 7.61	1.73, 2.11
Contopus sordidulus	5♂ 12.6±0.5	(2)1.26, 1.35	...	(1)2.6	(2)7.15, 7.86	1.86, 1.91
Contopus lugubris	3♀ 21.01±0.76 20♂ 21.60±0.20	(24)1.16±0.03	(1)35.32, 32.93	(4)4.16±0.60	(14)5.56±0.13	(14)1.75±0.03
Empidonax flaviventris	7♀ 10.34±0.16 13♂ 11.72±0.28	(15)1.00±0.02	(3)24.83±0.34	(3)4.76±0.18	(13)6.33±0.13	(13)1.82±0.02
Empidonax flavescens	5♀ 11.97±0.38 6♂ 12.33±0.22	(15)1.01±0.02	(3)26.53±3.70	(7)4.76±0.15	(11)6.12±0.21	(11)1.70±0.03
Mitrephanes phaeocercus	8♀ 8.28±0.09 8♂ 8.91±0.13	6♀ 1.40±0.04 P<0.01 8♂ 1.88±0.07	♀ 26.63 2♂ 27.90, 27.95	3.5, 3.68	(12)8.11±0.19	(12)1.75±0.02
Terenotriccus erythrurus	1♀ 6.45 1♂ 8.1	(2)1.05, 1.22	...	4.32	6.86, 7.16	1.71, 1.71
Myiobius sulphureipygius	4♀ 9.88±0.61 1♂ 10.0	(5)1.08±0.04	(3)24.36±0.47	(3)6.02±0.61	(4)6.56±0.25	(4)1.58±0.08

	Upper extremities: Pectoral and sup. *% body weight*	Upper extremities: Pectoralis *% body weight*	Upper extremities: Supra-coracoideus *% body weight*	"Rest" *% body weight*	Tail *cm.² per gram*	Glide *cm.² per gram*	Buoyancy index
Myiarchus ferox	(6)20.89±0.33	(4)18.97±1.05	(4)2.44±0.25	(4)8.12±0.44	(6)1.58±0.24	(6)7.40±0.46	4.10
Myiarchus tuberculifer	5♀ 19.3±0.28 P<0.01 11♂ 22.11±0.50	(4)20.1±0.84	(4)2.13±0.16	(4)7.24±0.69	(15)1.87±0.07	(15)8.26±0.13	3.99
Nuttallornis borealis	20.49	18.57	1.92	4.49	1.00	5.89	3.80
Contopus virens	17.96, 23.70	16.48, 19.32	1.48, 2.12	5.74, 6.50	2.17, 2.25	9.36, 10.6	4.09
Contopus sordidulus	20.5, 22.08	(1)20.0	2.08	...	1.96, 2.03	9.92, 11.11	4.08
Contopus lugubris	(15)21.61±0.42	(2)26.20, 25.00	(2)2.47, 2.04	(1)8.28	(14)1.59±0.08	(14)7.49±0.17	3.94
Empidonax flaviventris	(13)18.74±0.25	(5)17.4±0.10	(5)1.93±0.09	(3)5.60±0.29	(12)1.66±0.09	(13)8.56±0.04	3.79
Empidonax flavescens	5♀ 17.90±0.54 P<0.01 9♂ 24.05±0.89	♀ 16.2 4♂ 21.67±1.86	♀ 2.03 4♂ 2.35±0.31	(2)7.29, 7.47	(10)1.41±0.09	(11)8.11±0.23	3.73
Mitrephanes phaeocercus	5♀ 18.44±0.40 P<0.01 6♂ 20.53±0.26	♀ 16.8, 14.2 ♂ 18.2, 19.5	♀ 1.12, 1.69 ♂ 1.83, 1.97	♀ 7.72 ♂ 6.62, 7.73	(11)2.18±0.09	(12)11.00±0.26	4.04
Terenotriccus erythrurus	(2)18.9, 20.4	...	...	...	1.53, 1.72	9.46, 8.90	3.67
Myiobius sulphureipygius	(4)18.29±0.50	(4)16.1±0.81	(4)2.15±0.17	(3)6.64±0.09	(4)2.08±0.29	(4)8.48±0.08	3.76

	Body weight *grams*	Heart *% body weight*	Upper extremities *% body weight*	Lower extremities *% body weight*	Wings *cm.² per gram*	Aspect ratio
Myiobius atricaudus	1♂ 10.62	1.18	25.58	6.68	6.46	1.65
Myiophobus fasciatus	♂ 9.68	1.65	25.31	4.11	6.16	. . .
Onychorhynchus coronatus	3♀ 15.97±0.19 1♂ 19.83	(3)1.03±0.08	(2)25.14, 25.61	5.52, 5.59	6.93, 5.93	1.53, 1.70
Platyrinchus mystaceus	4♀ 9.65±0.18 2♂ 12.5, 12.3	(5)1.19±0.08	19.89, 19.42	(3)6.29±0.23	(6)6.04±0.16	(6)1.58±0.07
Cnipodectes subbrunneus	3♀ 21.94±0.05	(3)0.71±0.02	28.19	(3)3.79±0.09	(3)5.27±0.08	(3)1.63±0.07
Craspedoprion aequinoctialis	♂ 19.2 22.61	0.74	26.45	4.78	5.26	1.53
Tolmomyias sulphurescens	2♂ 11.63, 15.0	(1)0.89	. . .	4.30	6.10	1.52
Rhynchocyclus brevirostris	4♀ 24.83±1.03 7♂ 23.35±0.62	(10)0.83±0.04	4♂ 30.38±1.30	(7)4.44±0.37	(9)4.96±0.23	(11)1.56±0.03
Todirostrum cinereum	9♀ 6.34±0.16 14♂ 6.49±0.13	(13)1.08±0.03	(5)15.72±0.61	(4)8.72±0.49	(8)6.69±0.16	(8)1.64±0.02
Todirostrum sylvia	1♀ 7.70 2♂ 6.81, 8.05	(3)1.12±0.06	(2)16.96, 20.15	(3)7.21±0.46	5.72, 6.52	1.44, 1.51
Oncostoma olivaceum	2♀ 6.3, 7.08 1♂ 6.82	(3)0.98±0.03	. . .	5.11	(3)6.91±0.10	(3)1.66±0.01

	Upper extremities						
	Pectoral and sup. *% body weight*	Pectoralis *% body weight*	Supra-coracoideus *% body weight*	"Rest" *% body weight*	Tail *cm.² per gram*	Glide *cm.² per gram*	Buoyancy index
Myiobius atricaudus	18.05	16.00	2.05	7.53	2.05	9.32	3.78
Myiophobus fasciatus	18.78	17.00	1.78	6.53	1.98	8.76	3.63
Onychorhynchus coronatus	18.15, 17.84	16.7, 16.33	1.45, 1.51	6.99, 7.77	2.18, 1.72	9.68, 8.34	4.16
Platyrinchus mystaceus	(5)14.43±0.18	(5)13.12±0.19	(5)1.35±0.02	4.93, 5.42	(5)0.68±0.09	(6)7.22±0.18	3.63
Cnipodectes subbrunneus	(3)21.02±0.61	18.7	2.23	7.26	(3)1.53±0.06	(3)7.23±0.19	3.84
Craspedoprion aequinoctialis	21.05	18.85	2.20	5.40	1.68	7.48	3.78
Tolmomyias sulphurescens	19.60	. . .	. . .	. . .	2.15	8.96	3.79
Rhynchocyclus brevirostris	4♀ 20.45±0.86 6♂ 24.37±1.78	(5)22.35±1.93	(5)2.45±0.22	(4)9.63±0.95	(10)1.23±0.07	(10)6.43±0.32	3.73
Todirostrum cinereum	(8)11.64±0.18	(5)10.1±0.50	(5)1.12±0.09	(5)4.46±0.21	(8)1.00±0.13	(8)8.39±0.35	3.52
Todirostrum sylvia	(3)13.45±0.57	(2)11.4, 12.29	1.12, 1.53	4.44, 6.33	0.91	7.14, 8.44	3.49
Oncostoma olivaceum	1♀ 12.93 2♂ 14.70, 14.84	. . .	. . .	. . .	(3)1.20±0.03	(3)8.53±0.07	3.60

(*continued*)

TABLE I.—*continued*

	Body weight *grams*	Heart *% body weight*	Upper extremities *% body weight*	Lower extremities *% body weight*	Wings *$cm.^2$ per gram*	Aspect ratio
Lophotriccus pileatus	7♀ 6.93±0.15 9♂ 8.06±0.13	(12)1.04±0.04	(7)20.84±0.44	(7)4.68±0.21	(9)5.86±0.27	(10)1.64±0.04
Capsiempis flaveola	2♀ 6.80, 7.45 3♂ 7.85±0.62	(4)1.18±0.06	(4)23.36±0.94	(4)6.95±0.60	(5)6.14±0.07	(5)1.47±0.02
Serpophaga cinerea	3♀ 7.98±0.18 1♂ 8.31	(3)1.55±0.13	...	(1)5.95	(3)5.92±0.22	(3)1.64±0.05
Elaenia flavogaster	5♀ 24.7±0.11 13♂ 22.25±0.85	(7)1.37±0.10	1♀ 23.20 3♂ 29.89±0.57	(5)6.01±0.40	(5)4.87±0.33	(5)1.59±0.05
Elaenia frantzii	5♀ 19.81±1.02 6♂ 19.83±0.35	5♀ 1.07±0.05 4♂ 1.22±0.03	2♀ 27.03, 28.61 3♂ 33.20±0.26	(7)5.45±0.11	(8)5.56±0.19	(7)1.76±0.04
Elaenia chiriquensis	2♂218.2, 19.1	(2)1.48, 1.57	(2)33.30, 33.78	4.61, 5.27	5.49, 5.73	1.78, 1.94
Myiopagis viridicata	5♀ 12.75±0.33 7♂ 14.14±0.44	(8)1.04±0.04	(5)26.05±0.36	(6)5.97±0.28	(10)6.01±0.13	(10)1.67±0.03
Camptostoma obsoletum	2♀ 6.94, 7.00 2♂ 7.31, 8.12	(3)1.42±0.08	1♀ 24.52 2♂ 28.32, 29.42	(3)5.57±0.25	(3)6.84±0.44	(3)1.78±0.06
Tyranniscus vilissimus	5♀ 8.48±0.35 4♂ 9.29±0.33	(5)1.17±0.08	...	4.3	(5)6.27±0.31	(5)1.65±0.03
Tyranniscus elatus	1♀ 7.25 1♂ 7.34	(2)1.30, 1.32	(2)23.11, 24.06	4.92, 5.40	6.13, 6.62	1.69, 1.75
Acrochordopus zeledoni	1♂ 10.28	1.39	25.40	4.67	6.43	1.80

	Upper extremities						
	Pectoral and sup. *% body weight*	Pectoralis *% body weight*	Supra-coracoideus *% body weight*	"Rest" *% body weight*	Tail *$cm.^2$ per gram*	Glide *$cm.^2$ per gram*	Buoyancy index
Lophotriccus pileatus	(10)15.93±0.41	(8)13.8±0.28	(6)1.63±0.12	(7)5.23±0.36	(8)1.20±0.09	(10)7.62±0.33	3.39
Capsiempis flaveola	(4)16.78±1.02	(4)14.36±0.63	(4)1.75±0.09	(4)6.57±0.48	(5)1.36±0.18	(5)8.30±0.21	3.48
Serpophaga cinerea	19.49±0.44	(1)16.85	(1)2.21	...	(3)1.27±0.11	(3)7.78±0.11	3.49
Elaenia flavogaster	1♀ 17.27 6♂ 21.03±1.25	1♀ 15.7 4♂ 20.41±0.45	1♀ 1.57 4♂ 2.39±0.11	1♀ 6.03 3♂ 7.26±0.10	(5)1.71±0.11	(5)7.27±0.38	3.89
Elaenia frantzii	5♀ 20.30±0.38 4♂ 24.89±0.71	3♀ 18.26±0.41 3♂ 21.89±0.23	3♀ 2.20±0.19 3♂ 2.40±0.27	2♀ 7.34, 8.16 3♂ 8.88±0.18	(9)1.59±0.08	(10)7.59±0.23	3.88
Elaenia chiriquensis	25.62, 25.82	22.90, 23.30	2.52, 2.72	7.48, 8.16	1.52, 1.74	7.46, 8.27	3.88
Myiopagis viridicata	4♀ 18.80±0.61 3♂ 22.36±1.57	(6)16.85±0.35	(6)2.03±0.12	(5)6.92±0.15	(9)1.85±0.09	(9)8.38±0.19	3.78
Camptostoma obsoletum	1♀ 16.45 2♂ 21.67, 22.72	♀ 14.6 ♂ 18.71, 19.95	♀ 1.85 ♂ 2.77, 2.96	♀ 8.07 ♂ 6.65, 6.70	(3)1.07±0.11	(3)8.74±0.60	3.67
Tyranniscus vilissimus	3♀ 15.8±0.32 1♂ 21.91	1♀ 13.4 1♂ 19.6	1♀ 2.55 1♂ 2.31	...	(4)1.35±0.20	(5)8.33±0.44	3.61
Tyranniscus elatus	18.12, 18.43	16.4, 16.5	1.72, 1.93	4.99, 5.63	1.24, 1.77	9.11, 9.13	3.75
Acrochordopus zeledoni	19.23	17.11	2.12	6.17	1.65	8.90	3.74

	Body weight *grams*	Heart *% body weight*	Upper extremities *% body weight*	Lower extremities *% body weight*	Wings *cm.² per gram*	Aspect ratio
Leptopogon superciliaris	3♀ 11.41±0.35 2♂ 13.15, 13.77	(15)1.08±0.06	(3)26.67±0.80	(3)4.55±0.04	(5)6.36±0.28	(4)1.58±0.04
Mionectes olivaccus	5♀ 13.65±0.76 6♂ 13.93±0.36	(9)1.41±0.05	♀ 23.22, 25.84 ♂ 29.84, 30.65	(7)4.97±0.35	(10)5.51±0.24	(9)1.66±0.03
Pipromorpha oleaginea	2♀ 9.6, 9.8 5♂ 11.93±0.27	(5)1.19±0.07	26.71, 37.02	(3)4.20±0.24	(4)6.00±0.36	(4)1.46±0.07
HIRUNDINIDAE						
Progne chalybea	6♀ 37.20±0.54 18♂ 39.66±0.65	(14)1.40±0.04	(5)24.05±1.28	(7)2.90±0.30	(14)3.89±0.09	(14)2.59±0.04
**Stelgidopteryx ruficollis*	6♀ 13.26±0.63 9♂ 14.51±0.54	(8)1.59±0.05	(4)25.55±0.31	(6)1.80±0.11	(9)7.49±0.24	(9)2.41±0.08
Pygochelidon cyanoleuca	7♀ 9.99±0.45 4♂ 10.49±0.37	(12)1.32±0.04	(4)19.70±0.27	(6)2.84±0.30	(7)7.89±0.30	(7)2.31±0.02
Iridoprocne albilinea	1♀ 13.53 3♂ 13.60±0.49	(4)1.61±0.17	(4)21.66±1.52	(3)2.53±0.12	(3)6.60±0.53	(3)2.46±0.06
CORVIDAE						
Corvus brachyrhynchos pascuus	6♀ 438±30.6 6♂ 457.6±35.8	(8)1.06±0.03	. . .	. . .	(3)2.89±0.13	1.83, 1.88
Cyanocorax affinis	2♀ 210,221 1♂ 204	(3)0.85±0.02	(1)22.40	(2)14.4, 16.34	(3)2.65±0.10	(3)1.56±0.06

	Upper extremities: Pectoral and sup. *% body weight*	Upper extremities: Pectoralis *% body weight*	Upper extremities: Supra-coracoideus *% body weight*	"Rest" *% body weight*	Tail *cm.² per gram*	Glide *cm.² per gram*	Buoyancy index
Leptopogon superciliaris	(5)20.12±0.39	(5)17.93±0.36	(5)2.19±0.05	(3)7.36±0.45	(5)1.73±0.14	(5)8.77±0.40	3.87
Mionectes olivaceus	5♀ 18.50±0.98 5♂ 22.19±0.62	3♀ 17.45±0.59 4♂ 20.0±0.70	3♀ 2.08±0.10 4♂ 2.32±0.14	2♀ 4.68, 6.11 2♂ 7.12, 7.30	(9)1.14±0.08	(10)7.09±0.27	3.58
Pipromorpha oleaginea	(4)24.48±2.01	18.4, 25.8	2.37, 3.14	5.94, 8.08	(4)1.11±0.09	(4)8.00±0.51	3.71
HIRUNDINIDAE							
Progne chalybea	(15)17.69±0.31	(5)16.75±0.67	(5)1.39±0.05	(5)5.91±0.65	(13)0.76±0.03	(13)5.08±0.13	3.56
**Stelgidopteryx ruficollis*	(8)20.43±1.39	(4)17.74±2.31	(4)1.62±0.25	(4)6.19±0.93	(9)1.46±0.13	(9)9.55±0.33	4.30
Pygochelidon cyanoleuca	(7)14.70±0.34	(4)13.7±0.05	(4)1.25±0.11	(4)4.75±0.26	(7)1.55±0.10	(7)10.19±0.38	4.16
Iridoprocne albilinea	(4)16.99±1.03	(4)15.69±0.88	(4)1.30±0.27	(3)5.09±0.62	(4)1.00±0.25	(3)8.72±1.01	3.98
CORVIDAE							
Corvus brachyrhynchos pascuus	(3)14.2±0.33	. . .	. . .	. . .	(3)0.46±0.06	(3)3.63±0.23	4.70
Cyanocorax affinis	(3)12.45±0.64	(1)12.36	1.01	9.03	(3)0.83±0.01	(3)3.70±0.12	4.02

(continued)

TABLE I.—*continued*

	Body weight *grams*	Heart *% body weight*	Upper extremities *% body weight*	Lower extremities *% body weight*	Wings *cm.² per gram*	Aspect ratio
Cyanolyca argentigula	1♀ 190 1♂ 210	0.90, 0.92	19.54	15.05	2.52, 2.58	1.40, 1.50
Aphelocoma coerulescens	12♀ 71.6±1.01 16♂ 75.79±1.24	(13)0.94±0.03	(2)19.55, 21.02	12.8, 14.5	(13)2.89±0.08	(13)1.54±0.02
**Cyanocitta cristata bromia*	8♀ 88.7±1.75 5♂ 92.3±1.24	(7)1.02±0.04	(4)23.67±0.42	(4)10.6±0.22	(4)3.33±0.05	(4)1.57±0.04
Cyanocitta cristata cristata	10♀ 70.71±1.30 P<0.01 11♂ 77.38±1.31	(21)0.99±0.02	(9)25.48±0.37	(9)11.0±0.19	(21)3.46±0.07	(21)1.53±0.02
PARIDAE						
Parus carolinensis	24♀ 9.79±0.12 P<0.01 18♂ 10.52±0.17	(5)1.49±0.06	(5)23.73±0.89	(5)7.18±0.21	(6)6.59±0.11	(6)1.62±0.03
**Parus bicolor*	17♀ 20.44±0.40 P<0.01 20♂ 22.13±0.30	(11)1.35±0.05	(7)27.38±0.45	(7)7.35±0.21	(11)5.21±0.17	(11)1.60±0.02
SITTIDAE						
**Sitta carolinensis*	29♀ 20.7±0.23 22♂ 21.0±0.25	(16)1.29±0.03	(5)24.08	(5)8.37±0.16	(5)5.85±0.16	(5)1.95±0.02
Sitta pusilla	5♀ 9.14±0.21 5♂ 9.60±0.25	(10)1.22±0.07	. . .	. . .	(10)6.56±0.02	1.63±0.02
CERTHIIDAE						
**Certhia familiaris*	7♀ 8.21±0.24 14♂ 8.60±0.16	(9)1.48±0.04	(6)23.17±0.45	(7)5.95±0.17	(7)8.59±0.14	(7)1.65±0.02

	Upper extremities						
	Pectoral and sup. *% body weight*	Pectoralis *% body weight*	Supra-coracoideus *% body weight*	"Rest" *% body weight*	Tail *cm.² per gram*	Glide *cm.² per gram*	Buoyancy index
Cyanolyca argentigula	12.18, 12.85	11.2, 11.9	0.95, 0.98	7.34	0.69, 0.75	3.62, 3.63	3.86
Aphelocoma coerulescens	(11)11.78±0.11	(2)11.3, 12.9	1.03, 1.22	6.9, 7.22	(13)1.16±0.08	(13)4.38±0.16	3.44
**Cyanocitta cristata bromia*	(4)16.21±0.23	(4)15.0±0.24	(4)1.21±0.06	(4)7.68±0.05	(4)1.32±0.04	(4)5.10±0.02	3.87
Cyanocitta cristata cristata	(21)15.72±0.36	(9)16.0±0.23	(9)1.27±0.04	(9)8.21	(21)1.15±0.07	(21)5.16±0.12	3.86
PARIDAE							
Parus carolinensis	(5)18.07±0.46	(5)16.62±0.42	(5)1.45±0.11	(4)6.21±0.27	(5)2.22±0.22	(6)9.42±0.39	3.79
**Parus bicolor*	(11)18.25±0.69	(7)17.94±0.31	(7)1.71±0.13	(7)7.71±0.16	(9)1.43±0.10	(11)7.33±0.23	3.80
SITTIDAE							
**Sitta carolinensis*	(5)17.66±0.24	(5)16.37±0.24	(5)1.29±0.24	(5)6.41±0.02	(5)1.10±0.06	(5)7.65±0.18	4.02
Sitta pusilla	(10)14.5±0.43	. . .	. . .	. . .	0.81±0.03	8.31	3.72
CERTHIIDAE							
**Certhia familiaris*	(6)17.38±0.46	(6)16.16±0.50	(6)1.38±0.08	(6)5.62±0.10	(6)2.35±0.09	(7)11.80±0.16	4.22

	Body weight *grams*	Heart *% body weight*	Upper extremities *% body weight*	Lower extremities *% body weight*	Wings *cm.² per gram*	Aspect ratio
TROGLODYTIDAE						
Thryothorus ludovicianus	4♀ 19.2±1.00 11♂ 21.6±0.56	(7)1.02±0.06	(1)20.27	(1)13.2	(6)3.28±0.13	(6)1.55±0.03
Thryothorus modestus	7♀ 17.90±0.50 6♂ 19.73±0.38 P<0.01	5♀ 0.85±0.04 P<0.01 7♂ 1.19±0.10	(3)15.65±0.35	(5)11.7±0.84	(11)3.77±0.11	(11)1.55±0.06
**Thryothorus leucotis*	6♀ 18.69±0.56 9♂ 20.03±0.41	(10)0.86±0.03	(5)17.69±0.69	(6)12.62±0.34	(7)4.17±0.20	(6)1.47±0.03
Thryothorus fasciato-ventris	3♀ 23.01±1.00	(3)0.77±0.03	(2)16.97, 18.13	(3)12.10±0.77	(3)3.67±0.02	(3)1.46±0.05
Thryothorus rutilus	2♀ 13.72, 13.62 4♂ 16.64±0.06	(5)0.99±0.04	18.03, 18.32	(4)11.0±0.43	(5)4.28±0.09	(4)1.53±0.05
Troglodytes musculus	7♀ 15.65±0.65 12♂ 14.76±0.21	(15)1.18±0.04	(7)20.24±0.67	(7)12.00±0.20	(14)3.84±0.10	(13)1.55±0.03
Troglodytes ochraceus	2♀ 9.35, 10.0 1♂ 10.0	(3)1.18±0.10	(1)16.85	(3)10.07±0.36	(3)4.54±0.37	(3)1.40±0.05
Henicorhina leucosticta	5♀ 16.48±0.14 6♂ 17.89±0.66	(8)1.03±0.06	(3)20.40±1.11	(4)12.7±0.47	(8)3.98±0.16	(7)1.48±0.04
Henicorhina leucophrys	6♀ 16.36±0.36 17♂ 18.1±0.25	(15)1.08±0.03	(6)16.43±0.39	(8)12.83±0.31	(14)4.06±0.08	(14)1.49±0.03
Leucolepis phaeocephalus	5♂ 27.08±0.60	(5)0.80±0.02	(3)26.98±2.27	(4)12.17±0.54	(4)3.54±0.06	(4)1.64±0.04

	Upper extremities						
	Pectoral and sup. *% body weight*	Pectoralis *% body weight*	Supra-coracoideus *% body weight*	"Rest" *% body weight*	Tail *cm.² per gram*	Glide *cm.² per gram*	Buoyancy index
TROGLODYTIDAE							
Thryothorus ludovicianus	(6)13.5±0.61	(1)12.6	(1)1.41	(1)6.26	(5)0.75±0.09	(6)4.57±0.18	2.99
Thryothorus modestus	4♀ 10.8±0.37 7♂ 13.07±0.68 P<0.01	(4)9.13±0.32	(4)1.04±0.08	(3)5.30±0.29	(10)0.71±0.04	(11)4.96±0.14	3.12
**Thryothorus leucotis*	(7)11.51±0.40	(5)10.70±0.48	(4)1.30±0.15	(5)5.80±0.15	(7)0.70±0.04	(7)5.42±0.12	3.39
Thryothorus fasciato-ventris	(3)12.12±0.43	10.85, 10.30	1.20, 1.25	5.42, 6.08	(3)0.56±0.07	(3)4.75±0.22	3.19
Thryothorus rutilus	(5)12.38±0.14	(3)11.3±0.07	(3)1.27±0.06	5.55, 5.83	(4)1.18±0.07	(5)5.82±0.27	3.27
Troglodytes musculus	(15)14.06±0.25	(9)12.52±0.31	(9)1.48±0.07	(7)6.13±0.26	(13)0.72±0.03	(14)5.09±0.14	3.02
Troglodytes ochraceus	(3)11.87±0.46	(1)10.60	1.11	5.14	(3)0.63±0.04	(3)5.71±0.40	3.25
Henicorhina leucosticta	(8)12.88±0.69	(5)11.42±0.70	(4)1.45±0.05	(3)5.61±0.21	(8)0.46±0.07	(8)4.89±0.28	3.21
Henicorhina leucophrys	(14)11.31±0.21	(7)10.25±0.19	(7)1.04±0.03	(4)4.78±0.19	(13)0.41±0.03	(14)4.86±0.11	3.26
Leucolepis phaeocephalus	(5)19.02±1.20	(3)17.31±2.02	(3)2.09±0.30	(3)7.54±0.33	(4)0.27±0.03	(4)4.21±0.07	3.25

(*continued*)

TABLE I.—*continued*

	Body weight *grams*	Heart *% body weight*	Upper extremities *% body weight*	Lower extremities *% body weight*	Wings *$cm.^2$ per gram*	Aspect ratio
MIMIDAE						
Dumetella carolinensis	8♀ 38.8±1.56 10♂ 38.20±1.38	(5)1.09±0.05	(2)19.35, 19.89	8.24, 8.64	(2)3.53, 4.36	1.73, 1.76
**Mimus polyglottos*	15♀ 48.4±1.19 14♂ 53.4±1.46	(10)1.12±0.03	(7)23.15±0.72	(7)9.65±0.28	(11)4.11±0.12	(11)1.67±0.03
TURDIDAE						
Turdus assimilis	10♂ 67.50±1.90	(8)1.31±0.06	(3)31.06±0.44	(5)7.29±0.41	(8)3.56±0.12	(8)1.79±0.03
Turdus grayi	6♀ 76.66±2.27 10♂ 72.69±1.17	(11)1.04±0.05	4♂ 32.89±0.99	(4)7.25±0.22	(8)3.29±0.16	(8)1.77±0.03
Turdus plebejus	5♀ 91.93±2.35 $P < 0.01$ 16♂ 81.12±2.39	(21)1.22±0.05	(3)36.53±0.99	(4)7.56±0.35	(16)3.38±0.09	(16)1.85±0.03
Myadestes melanops	3♀ 32.07±2.42 6♂ 32.08±0.63	(8)1.03±0.01	(1)25.06	4.75, 4.94	(8)4.17±0.10	(8)1.73±0.03
**Hylocichla ustulata*	2♀ 39.73, 30.19 7♂ 30.61±0.96	(6)1.14±0.06	(4)27.30±0.57	(6)5.60±1.94	(6)4.12±0.21	(6)1.87±0.07
Catharus frantzii	1♂ 31.4	(1)1.38	(1)24.07	11.78	4.20	1.48
Catharus griseiceps	5♀ 30.87±0.57 1♂ 28.53	(5)0.82±0.04	(1)20.17	(1)9.47	(3)3.27±0.30	(3)1.53±0.01

	Upper extremities						
	Pectoral and sup. *% body weight*	Pectoralis *% body weight*	Supra-coracoideus *% body weight*	"Rest" *% body weight*	Tail *$cm.^2$ per gram*	Glide *$cm.^2$ per gram*	Buoyancy index
MIMIDAE							
Dumetella carolinensis	13.75, 14.31	12.62, 13.02	1.13, 1.31	5.56, 5.60	1.90, 2.31	5.79, 7.18	3.67
**Mimus polyglottos*	(11)15.99±0.48	(7)14.8±0.66	(7)1.41±0.05	(7)6.94±0.05	(11)1.67±0.14	(11)6.33±0.24	3.75
TURDIDAE							
Turdus assimilis	(8)22.50±0.75	(3)20.75±0.35	(3)2.06±0.06	(3)8.25±0.05	(8)0.95±0.07	(8)4.83±0.18	3.81
Turdus grayi	2♀ 18.7, 19.8 6♂ 23.36±0.51	4♂ 21.29±0.60	4♂ 2.32±0.23	(4)9.28±0.24	(8)0.81±0.08	(8)4.48±0.05	3.79
Turdus plebejus	(16)21.98±0.70	(3)23.9±0.50	(3)2.25±0.06	(3)10.01±0.11	(15)0.84±0.04	(16)4.52±0.15	3.85
Myadestes melanops	(7)18.65±0.53	(3)17.3±0.46	(3)1.74±0.10	6.72	(8)1.30±0.09	(8)5.55±0.40	3.62
**Hylocichla ustulata*	(5)19.58±0.61	4♂ 18.57±0.36 1♀ 13.20	4♂ 1.73±0.04 ♀ 1.40	4♂ 7.03±0.27 ♀ 4.98	(6)1.24±0.05	(6)5.95±0.23	3.61
Catharus frantzii	16.88	15.29	1.59	7.19	1.15	5.65	3.64
Catharus griseiceps	(4)14.23±0.56	(3)12.87±0.58	(3)1.54±0.22	6.40	(3)0.76±0.10	(3)4.47±0.27	3.20

	Body weight *grams*	Heart *% body weight*	Upper extremities *% body weight*	Lower extremities *% body weight*	Wings *cm.² per gram*	Aspect ratio
Sialia sialis	15♀ 32.6±0.78 18♂ 30.8±0.48	(7)1.17±0.06	...	...	(9)4.41±0.23	1.95±0.07
SYLVIIDAE **Polioptila plumbea*	2♀ 6.07, 6.56 2♂ 6.80, 5.90	(4)1.19±0.15	(3)19.66±0.12	(4)6.55±0.52	(4)7.14±0.18	(4)1.64±0.04
Ramphocaenus rufiventris	2♂ 9.37, 10.08	(1)1.58, 1.10	(1)16.77	(1)9.72	(2)5.76, 4.15	1.38, 1.44
MOTACILLIDAE **Anthus parvus*	5♀ 12.35±0.47 9♂ 12.67±0.18	(14)1.57±0.03	(3)27.99±0.89	(3)5.99±0.44	(14)5.62±0.09	(14)1.77±0.02
BOMBYCILLIDAE **Bombycilla cedrorum*	13♀ 33.9±0.68 28♂ 31.9±0.74	(18)1.54±0.03	(4)28.81±1.34	(4)3.98±0.43	(3)3.40±0.24	(3)2.13±0.08
PTILOGONATIDAE **Ptilogonys caudatus*	1♀ 33.5 4♂ 39.1±0.96	(5)1.33±0.04	...	4.93	(2)4.43, 4.13	1.63, 1.65
LANIIDAE **Lanius ludovicianus*	9♀ 48.1±0.05 11♂ 47.4±0.03	(12)1.19±0.003	...	...	(6)3.36±0.03	1.77±0.01

	Upper extremities						
	Pectoral and sup. *% body weight*	Pectoralis *% body weight*	Supra-coracoideus *% body weight*	"Rest" *% body weight*	Tail *cm.² per gram*	Glide *cm.² per gram*	Buoyancy index
Sialia sialis	(7)16.8±0.63	...	...	...	(9)0.67±0.02	5.54±0.27	3.73
SYLVIIDAE **Polioptila plumbea*	(4)13.95±0.68	(3)12.87±0.76	(3)1.03±0.01	(3)5.76±0.54	(4)1.60±0.20	(4)9.42±0.44	3.53
Ramphocaenus rufiventris	10.95	(2)9.93, 11.6	(2)0.94, 1.02	(1)5.62	1.07, 0.75	7.36, 5.40	3.25
MOTACILLIDAE **Anthus parvus*	(14)21.54±0.20	(3)19.9±0.57	(3)1.27±0.38	(3)6.85±0.47	(13)0.83±0.05	(14)7.05±0.10	3.66
BOMBYCILLIDAE **Bombycilla cedrorum*	(4)22.64±1.29	(4)20.8±1.19	(4)1.84±0.13	(4)6.17±0.15	(3)0.75±0.07	(3)4.57±0.32	3.29
PTILOGONATIDAE **Ptilogonys caudatus*	(2)19.3, 18.5	...	...	...	1.81, 1.07	5.86, 6.41	3.80
LANIIDAE **Lanius ludovicianus*	(6)14.4±0.11	...	...	...	0.88±0.006	4.84±0.03	3.50

(continued)

TABLE I.—*continued*

	Body weight *grams*	Heart *% body weight*	Upper extremities *% body weight*	Lower extremities *% body weight*	Wings *cm.² per gram*	Aspect ratio
STURNIDAE **Sturnus vulgaris*	6♀ 76.5±2.72 5♂ 89.0±6.25	(8)1.29±0.05	(3)27.55±1.05	(5)7.76±0.24	(5)2.30±0.19	(5)2.19±0.07
CYCLARHIDAE **Cyclarhis gujanensis*	5♀ 31.89±0.91 4♂ 30.22±0.78	(6)0.97±0.06	(3)20.42±0.75	(3)9.99±0.34	(4)3.45±0.23	(3)1.62±0.01
VIREONIDAE *Vireo carmioli*	1♀ 13.4 3♂ 12.99±0.36	(4)1.02±0.03	...	7.1	6.40	1.71
**Vireo flavifrons*	4♀ 18.85±0.45 5♂ 16.9±0.23	(5)1.13±0.06	(4)22.65±0.42	(4)6.55±0.14	(5)4.49±0.33	(5)1.97±0.04
Vireo olivaceus	19♀ 16.45±0.42 21♂ 17.7±0.28	(18)1.43±0.04	(3)24.44±0.80	(3)5.89±0.38	(3)5.65±0.25	(3)1.89±0.04
Vireo philadelphicus	5♀ 11.6±0.25 8♂ 10.9±0.21	(9)1.32±0.04	25.50	(3)6.61±0.64	(10)6.23±0.12	(10)1.79±0.03
Vireo leucophrys	3♀ 9.33±0.83 3♂ 9.39±0.08	(2)1.16, 1.22	...	(2)6.53, 6.70	(2)6.16, 4.96	1.76, 1.58
Hylophilus aurantiifrons	3♀ 9.33±0.81 3♂ 9.40±0.08	(7)1.06±0.05	(4)20.94±0.87	(6)7.63±0.10	(7)5.99±0.13	(7)1.61±0.27
Hylophilus viridiflavus	1♀ 12.3 5♂ 12.05±0.71	1♀ 1.06 4♂ 1.35±0.10	(3)20.29±0.43	(4)8.61±0.14	(5)5.55±0.37	(4)1.48±0.05

	Upper extremities: Pectoral and sup. *% body weight*	Upper extremities: Pectoralis *% body weight*	Upper extremities: Supra-coracoideus *% body weight*	"Rest" *% body weight*	Tail *cm.² per gram*	Glide *cm.² per gram*	Buoyancy index
STURNIDAE **Sturnus vulgaris*	(5)20.12±0.46	(5)18.3±0.42	(5)1.80±0.08	(3)7.06±0.43	(5)0.37±0.06	(5)3.02±0.22	3.17
CYCLARHIDAE **Cyclarhis gujanensis*	(5)14.25±0.39	(5)13.11±0.39	(5)1.14±0.04	(3)6.24±0.03	(4)0.68±0.03	(4)4.85±0.10	3.41
VIREONIDAE *Vireo carmioli*	13.90	...	...	...	0.88	7.76	3.88
**Vireo flavifrons*	(5)17.60±0.58	(4)15.6±0.29	(4)1.50±0.15	(4)5.50±0.12	(5)0.96±0.14	(5)5.94±0.37	3.44
Vireo olivaceus	(3)18.55±1.36	(3)16.94±1.32	(3)1.59±0.07	(3)5.91±0.45	(3)1.08±0.15	(3)7.35±0.32	3.88
Vireo philadelphicus	8♀ 17.41±0.57 P<0.01 3♂ 13.90±0.14	♀ 12.7 ♂ 17.2	(1) ♀ 1.41 (1) ♂ 1.8	6.42	(12)1.19±0.05	(11)8.14±0.17	3.74
Vireo leucophrys	(2)14.15, 15.3	(1)12.84	1.31	6.61	1.53, 1.29	8.19, 6.85	3.41
Hylophilus aurantiifrons	(7)13.13±0.54	(4)12.65±0.55	(4)1.36±0.04	(4)6.93±0.54	(5)1.30±0.07	(7)7.78±0.24	3.57
Hylophilus viridiflavus	(5)13.92±0.59	(3)12.63±0.32	(3)1.31±0.17	(3)6.36±0.30	(3)1.14±0.10	(4)7.37±0.47	3.56

	Body weight *grams*	Heart *% body weight*	Upper extremities *% body weight*	Lower extremities *% body weight*	Wings *cm.² per gram*	Aspect ratio
Hylophilus decurtatus	3♀ 9.43±0.49 4♂ 9.94±0.31	(4)1.12±0.05	(5)20.72±1.25	(5)8.32±0.10	(5)5.90±0.25	(5)1.48±0.02
Hylophilus ochraceiceps	1♀ 16.78	1.34	...	...	3.73	1.42
COEREBIDAE						
**Chlorophanes spiza*	4♀ 18.71±0.89 4♂ 17.78±0.50	(5)1.28±0.06	(3)26.47±1.51	(5)8.07±0.48	(6)4.31±0.13	(6)1.68±0.04
Cyanerpes cyaneus	10♀ 13.20±0.29 15♂ 12.49±0.22	(17)1.44±0.03	(8)28.35±0.87	(10)5.98±0.21	(19)4.72±0.07	(19)1.82±0.02
Cyanerpes lucidus	2♀ 11.68, 11.76 4♂ 11.31±0.43	(6)1.32±0.05	(5)22.47±0.33	(6)7.01±0.31	(4)4.52±0.18	(3)1.76±0.01
Dacnis venusta	6♀ 16.04±0.41 37♂ 16.12±0.19	(37)1.35±0.02	(5)31.60±2.02	(8)6.26±0.44	(38)4.67±0.05	(39)1.83±0.02
PARULIDAE						
Mniotilta varia	18♀ 10.6±0.14 19♂ 10.3±0.14	(18)1.13±0.04	(5)23.04±0.80	(6)7.12±0.21	(9)7.09±0.29	(9)1.83±0.04
Protonatria citrea	4♀ 13.16±0.43 5♂ 14.09±0.30	(7)0.99±0.05	(4)22.13±0.82	(6)6.29±0.29	(8)5.73±0.16	(8)1.89±0.03
Helmitheros vermivorus	1♀ 12.90 2♂ 13.60, 13.47	(2)1.00, 1.03	...	8.70	5.86	1.78

	Upper extremities						
	Pectoral and sup. *% body weight*	Pectoralis *% body weight*	Supra-coracoideus *% body weight*	"Rest" *% body weight*	Tail *cm.² per gram*	Glide *cm.² per gram*	Buoyancy index
Hylophilus decurtatus	(4)13.92±0.62	(4)12.75±0.53	(5)1.21±0.10	(5)6.14±0.52	(5)0.99±0.08	(5)7.59±0.22	3.42
Hylophilus ochraceiceps	13.6	...	...	...	0.54	4.66	3.09
COEREBIDAE							
**Chlorophanes spiza*	(6)18.75±0.58	(3)16.58±0.60	(4)1.78±0.09	(3)7.05±0.70	(6)0.84±0.06	(6)5.63±0.16	3.36
Cyanerpes cyaneus	(11)20.62±0.65	(10)18.90±0.69	(10)1.85±0.16	(8)7.09±0.42	(19)0.87±0.03	(19)6.09±0.09	3.32
Cyanerpes lucidus	(6)17.49±0.46	(6)15.54±0.31	(6)1.78±0.17	(5)5.29±0.13	(4)0.53±0.06	(4)5.61±0.22	3.37
Dacnis venusta	(38)22.09±0.42	4♂ 22.3±0.13	3♂ 2.07±0.12	(5)8.39±0.54	(38)0.94±0.03	(39)6.11±0.06	3.39
PARULIDAE							
Mniotilta varia	(9)17.7±0.37	(5)15.8±0.52	(5)1.54±0.03	(5)5.71±0.29	(9)1.72±0.14	(9)9.52±0.41	3.91
Protonatria citrea	(8)16.44±0.34	(4)15.1±0.29	(4)1.52±0.14	(4)5.48±0.52	(8)1.12±0.08	(8)7.48±0.25	3.72
Helmitheros vermivorus	(1)20.68	18.9	1.78	...	1.11	7.65	3.73

(continued)

TABLE I.—*continued*

	Body weight *grams*	Heart *% body weight*	Upper extremities *% body weight*	Lower extremities *% body weight*	Wings *cm.² per gram*	Aspect ratio
Vermivora chrysoptera	1♀ 8.4 3♂ 8.92±0.30	(4)1.30±0.18	(2)24.41, 26.18	(3)7.00±0.32	(5)6.95±0.10	(6)1.74±0.02
Vermivora pinus	(1)8.92	1.05	...	...	7.12	1.79
Vermivora peregrina	7♀ 9.42±0.38 17♂ 9.40±0.06	(24)1.26±0.03	(3)21.88±0.77	(5)6.56±0.33	(23)6.86±1.20	(21)1.85±0.02
Vermivora gutturalis	4♀ 9.2±0.24 3♂ 9.9±0.28	(9)1.22±0.07	...	7.55	(6)6.85±0.20	(6)1.70±0.03
Parula pitiayumi	6♀ 6.61±0.15 P<0.01 10♂ 7.22±0.12	(16)1.34±0.04	(5)20.17±0.80	(6)7.05±0.32	(12)6.90±0.12	(15)1.69±0.03
Dendroica petechia	16♀ 9.6±0.40 17♂ 10.25±0.30	(8)1.40±0.11	(1)20.91	(2)6.18, 6.97	6.25	1.85
Dendroica virens	22♀ 8.64±0.12 26♂ 9.29±0.11	(15)1.26±0.04	(4)22.49±0.57	(6)6.35±0.37	(12)7.21±0.15	(9)1.84±0.02
Dendroica fusca	18♀ 9.5±0.14 12♂ 10.0±0.58	(18)1.14±0.03	(1)20.84	(2)5.3, 7.02	(9)6.51±0.41	1.98±0.02
Dendroica pensylvanica	17♀ 9.41±0.18 25♂ 9.49±0.14	(20)1.13±0.03	(3)20.21±0.94	(4)7.00±0.26	(10)7.03±0.23	(10)1.85±0.02
Dendroica pinus	3♀ 12.5±0.97 3♂ 12.0±0	(5)1.16±0.06	...	...	(5)5.93±0.38	1.76±0.06
Dendroica discolor	6♀ 11.5±0.43 3♂ 11.8±0.21	(11)1.17±0.04	...	...	(11)6.60±0.13	1.75±0.04

	Upper extremities						
	Pectoral and sup. *% body weight*	Pectoralis *% body weight*	Supra-coracoideus *% body weight*	"Rest" *% body weight*	Tail *cm.² per gram*	Glide *cm.² per gram*	Buoyancy index
Vermivora chrysoptera	(6)15.69±0.58	(3)15.35±1.31	(3)1.91±0.26	(1)6.56	(6)1.84±0.11	(5)9.46±0.25	4.05
Vermivora pinus	17.05	...	...	...	1.68	9.36	3.86
Vermivora peregrina	(16)17.05±0.25	(3)15.05±0.33	(3)1.63±0.15	(3)5.19±0.45	(23)1.42±0.05	(21)8.92±0.13	3.79
Vermivora gutturalis	(6)14.8±1.0	...	...	...	1.16±0.02	8.18±0.31	3.83
Parula pitiayumi	(16)14.99±0.31	(8)13.21±0.33	(8)1.37±0.09	(5)5.32±0.30	(12)1.44±0.07	(15)9.15±0.15	3.62
Dendroica petechia	(2)14.73, 15.0	(1)13.39	(1)1.34	(1)6.18	0.94	8.13	3.68
Dendroica virens	(11)16.35±0.35	(6)14.90±0.36	(5)1.45±0.02	(5)6.26±0.33	(8)1.68±0.06	(12)9.86±0.19	3.90
Dendroica fusca	(10)15.7±0.20	(1)14.40	(1)1.42	5.02	(9)1.77±0.01	8.69±0.51	3.74
Dendroica pensylvanica	(10)15.21±0.44	(3)13.61±0.71	(3)1.51±0.17	(3)5.09±0.16	(9)1.92±0.13	(10)9.73±0.30	3.66
Dendroica pinus	(5)14.9±0.81	...	...	...	1.23±0.12	8.02±0.09	3.71
Dendroica	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]

	Body weight *grams*	Heart *% body weight*	Upper extremities *% body weight*	Lower extremities *% body weight*	Wings *cm.² per gram*	Aspect ratio
**Seiurus aurocapillus*	9♀ 18.86±0.49 12♂ 19.38±0.50	(15)1.17±0.03	(5)25.43±0.83	(5)6.10±0.12	(5)5.08±0.18	(5)1.84±0.48
Seiurus noveboracensis	6♀ 18.8±1.12 7♂ 16.4±0.98	(5)1.03±0.07	(3)25.84±1.21	(4)6.89±0.34	(5)6.86±0.17	(5)1.79±0.05
Seiurus motacilla	2♀ 18.1, 20.02	(2)1.20, 1.27	(1)29.59	(2)6.63, 6.40	(2)5.05, 5.13	1.83
Oporornis formosus	2♀ 13.92, 14.61 4♂ 14.48±0.89	(6)1.14±0.07	(4)23.35±0.23	(4)9.07±0.77	(6)5.05±0.19	(4)1.89±0.05
Oporornis philadelphia	4♀ 11.20±0.47 8♂ 11.69±0.17	(9)0.98±0.02	(4)20.51±0.86	(5)8.82±0.44	(5)5.58±0.08	(5)1.72±0.04
Geothlypis chiriquensis	1♀ 13.77 1♂ 14.70	(1)1.31	...	11.20	4.68	1.56
Icteria virens	3♀ 30.03±1.02 6♂ 24.73±0.42	(5)0.96±0.08	20.07	8.16	4.16	1.72
Wilsonia pusilla	12♀ 7.10±0.16 18♂ 7.47±0.06	(26)1.18±0.04	(5)20.21±0.75	(6)7.47±0.45	(18)7.38±0.09	(18)1.68±0.02
Setophaga ruticilla	11♀ 8.13±0.18 9♂ 7.9±0.21	(13)1.20±0.03	(3)22.14±1.29	(3)6.68±0.64	(4)7.93±0.34	(4)1.64±0.03
Myioborus miniatus	10♀ 9.41±0.43 27♂ 9.51±0.08	(32)1.39±0.03	(6)24.78±0.11	(8)7.10±0.45	(26)7.88±0.17	(25)1.54±0.05

	Upper extremities						
	Pectoral and sup. *% body weight*	Pectoralis *% body weight*	Supra-coracoideus *% body weight*	"Rest" *% body weight*	Tail *cm.² per gram*	Glide *cm.² per gram*	Buoyancy index
**Seiurus aurocapillus*	(5)19.26±0.73	(5)17.33±0.72	(5)1.94±0.12	(5)6.16±0.20	(4)1.38±0.21	(5)7.01±0.18	3.70
Seiurus noveboracensis	(5)18.93±0.39	(3)17.48±0.93	(3)1.93±0.03	(3)6.43±0.32	(4)1.35±0.12	(5)7.83±0.31	4.16
Seiurus motacilla	(2)21.52, 23.00	19.2	2.32	8.07	(2)1.17, 1.12	6.74, 6.77	3.68
Oporornis formosus	(4)17.59±0.26	(4)15.80±0.34	(3)1.72±0.07	(4)5.77±0.13	(6)1.23±0.06	(6)6.90±0.27	3.50
Oporornis philadelphia	(5)15.68±0.60	(4)13.75±0.57	(4)1.66±0.14	(4)5.11±0.45	(4)1.13±0.03	(5)7.48±0.13	3.60
Geothlypis chiriquensis	12.30	...	...	...	1.90	6.56	3.39
Icteria virens	14.59	13.1	1.49	5.48	1.29	5.96	3.50
Wilsonia pusilla	(20)14.20±0.21	(5)13.19±0.49	(5)1.41±0.08	(6)5.55±0.21	(17)2.04±0.07	(18)10.11±0.12	3.80
Setophaga ruticilla	(4)16.26±0.52	(3)15.2±0.35	(3)1.48±0.04	(3)5.49±0.59	(4)2.65±0.45	(4)11.82±0.62	3.97
Myioborus miniatus	(29)15.78±0.38	(6)15.88±0.30	(6)1.63±0.10	(6)7.39±0.70	(26)2.45±0.09	(26)11.12±0.22	4.10

(*continued*)

TABLE 1.—*continued*

	Body weight *grams*	Heart *% body weight*	Upper extremities *% body weight*	Lower extremities *% body weight*	Wings *cm.² per gram*	Aspect ratio
Myioborus torquatus	3♀ 10.28±0.14 2♂ 10.12, 11.12	(5)1.18±0.06	(4)21.10±1.40	(4)7.84±0.31	(5)7.49±0.26	(4)1.55±0.06
Basileuterus culicivorus	7♀ 11.14±0.52 8♂ 12.14±0.63	(16)1.37±0.07	(4)20.78±1.22	(5)8.10±0.28	(15)5.84±0.09	(15)1.57±0.03
Basileuterus melanogenys	4♀ 11.78±0.12 5♂ 11.78±0.60	(5)1.07±0.05	(1)15.42	10.2, 10.38	(7)5.98±0.25	(6)1.54±0.02
Phaeothlypis fulvicauda	2♀ 14.32, 15.50 2♂ 14.15, 16.48	(5)1.12±0.04	(3)23.20±0.74	(3)9.73±0.61	(5)4.87±0.19	(4)1.55±0.05
PLOCEIDAE *Passer domesticus*	27♀ 26.15±0.56 28♂ 27.78±0.49	(22)1.39±0.03	(15)25.37±0.32	(19)6.47±0.14	(19)3.10±0.05	(20)1.88±0.08
ICTERIDAE *Zarhynchus wagleri*	7♀ 112.7±2.30 9♂ 214.0±0.41	(13)1.10±0.03	(6)24.92±0.59	(7)9.36±0.38	(12)2.93±0.13	(12)1.99±0.04
Psarocolius decumanus	1♀ 170 4♂ 314±0.88	(4)0.91±0.06	(5)23.54±0.38	(5)12.44±0.67	(5)2.44±0.14	(5)2.03±0.04
Cacicus vitellinus	10♀ 68.35±0.99 11♂ 113.1±2.49	(12)1.05±0.02	(5)21.66±0.18	(6)9.11±0.57	(9)3.57±0.11	(10)1.93±0.06
Cacicus microrhynchus	2♀ 52.7, 57.40 2♂ 56.5, 69.00	(4)1.08±0.03	(3)23.49±1.95	(3)9.91±1.37	(4)3.89±0.15	(4)1.74±0.10

	Upper extremities						
	Pectoral and sup. *% body weight*	Pectoralis *% body weight*	Supra-coracoideus *% body weight*	"Rest" *% body weight*	Tail *cm.² per gram*	Glide *cm.² per gram*	Buoyancy index
Myioborus torquatus	(5)14.75±0.73	(4)13.40±1.03	(4)1.25±0.04	(4)6.43±0.37	(4)1.96±0.15	(5)10.04±0.32	4.03
Basileuterus culicivorus	(14)14.59±0.54	(4)12.56±0.49	(4)1.29±0.11	(3)5.30±0.78	(15)1.66±0.06	(15)8.07±0.12	3.64
Basileuterus melanogenys	(4)12.7±0.60	9.45	(2)1.10, 1.38	4.87	(6)1.47±0.10	(7)8.09±0.28	3.81
Phaeothlypis fulvicauda	(4)16.29±0.42	(4)14.56±0.48	(5)1.75±0.07	(3)6.83±0.30	(5)1.22±0.10	(5)7.08±0.28	3.43
PLOCEIDAE *Passer domesticus*	(20)18.83±0.26	(20)17.1±0.24	(20)1.71±0.05	(15)6.29±0.12	(19)0.74±0.03	(19)4.45±0.08	3.05
ICTERIDAE *Zarhynchus wagleri*	(12)17.22±0.38	(6)15.69±0.30	(6)1.33±0.05	(6)7.90±0.32	(12)0.63±0.04	(12)3.75±0.16	3.77
Psarocolius decumanus	(5)15.28±0.16	(5)14.03±0.16	(5)1.25±0.04	(5)8.25±0.23	(3)0.85±0.12	(5)3.44±0.21	4.04
Cacicus vitellinus	(10)16.71±0.42	(5)14.2±0.10	(5)1.25±0.07	(5)6.18±0.49	(8)0.78±0.05	(8)4.65±0.19	4.41
Cacicus microrhynchus	(4)15.64±0.96	(4)14.80±1.00	(4)1.34±0.05	(3)6.92±0.68	(4)0.67±0.01	(4)5.00±0.23	3.83

	Body weight grams	Heart % body weight	extremities % body weight	extremities % body weight	cm.² per gram	Aspect ratio
Amblycercus holosericeus	4♀ 56.4±0.73 13♂ 71.0±1.21	(9)0.91±0.02	(5)19.20±0.78	(3)15.23±0.67	(4)2.50±0.12	(4)1.31±0.07
Psomocolax oryzivorus	2♀ 132.60, 149.44 2♂ 175.30, 200	(4)1.18±0.03	(4)26.84±0.20	(4)9.32±0.24	(3)2.48±0.07	(4)1.96±0.04
Cassidix mexicanus	8♀ 100.5±3.00 20♂ 191.0±6.04	(22)0.98±0.02	1♀ 27.04 3♂ 23.61±1.05	2♀ 10.0, 11.0 3♂ 12.6±0.46	4♀ 2.91±0.14 P<0.05 5♂ 2.37±0.10	(9)1.83±0.03
Icterus spurius	1♀ 32.42 6♂ 24.06±1.22	(4)0.94±0.05	(5)21.89±0.97	(5)7.46±0.34	(5)4.01±0.40	(5)1.85±0.05
Icterus mesomelas	4♀ 50.75±1.50 5♂ 56.21±2.98	(7)0.91±0.06	(4)21.38±1.09	(4)12.16±0.13	(4)3.32±0.15	(4)1.59±0.06
Icterus galbula	4♀ 33.46±0.98 10♂ 33.82±0.48	(12)1.27±0.06	(2)25.48, 27.47	(3)8.12±0.11	(7)4.16±0.12	(7)1.84±0.34
Agelaius phoeniceus	4♀ 34.0±2.71 9♂ 50.7±0.79	(7)1.08±0.04	2♂ 26.89, 26.91	8.86, 8.94	(8)3.87±0.17	(6)1.61±0.04
Leistes militaris	4♀ 35.48±0.27 9♂ 46.16±0.83	(12)0.91±0.02	(3)28.00±0.54	(4)13.5±0.03	(12)3.86±0.10	(12)1.78±0.02
Sturnella magna (Panamá)	6♀ 72.61±2.95 8♂ 98.22±1.95	(13)0.85±0.02 P<0.01	(3)26.39±1.15	(4)14.91±0.17	(13)2.22±0.08	(13)1.83±0.08
Sturnella magna (Florida)	3♀ 73.0±5.26 8♂ 97.8±2.5	(11)1.08±0.02	...	...	(10)2.16±0.04	(10)1.68±0.03
THRAUPIDAE *Chlorophonia callophrys*	2♀ 25.2, 28.1 4♂ 25.4±1.02	(7)1.27±0.06	...	(3)7.15±0.09	(7)3.73±0.13	1.78±0.05

	Upper extremities: Pectoral and sup. % body weight	Upper extremities: Pectoralis % body weight	Upper extremities: Supra-coracoideus % body weight	"Rest" % body weight	Tail cm.² per gram	Glide cm.² per gram	Buoyancy index
Amblycercus holosericeus	(6)12.71±0.63	(5)11.86±0.51	(5)1.09±0.08	(3)6.52±0.42	(4)0.83±0.10	(4)3.82±0.26	3.87
Psomocolax oryzivorus	(4)18.44±0.05	(4)16.84±0.03	(4)1.60±0.03	(4)8.41±0.16	(4)0.71±0.04	(3)3.49±0.08	3.65
Cassidix mexicanus	4♀ 14.09±1.15 5♂ 15.66±0.59	1♀ 15.25 3♂ 14.8±0.66	1♀ 1.41 3♂ 1.50±0.08	2♀ 6.68, 7.37 3♂ 7.27±0.52	(9)0.79±0.09	4♀ 3.99±0.24 5♂ 3.68±0.18	3.67♀ 3.63♂
Icterus spurius	(5)15.76±0.87	(5)14.48±0.81	(5)1.28±0.14	(5)6.12±0.19	(4)0.69±0.12	(5)5.13±0.49	3.45
Icterus mesomelas	(4)14.47±0.69	(4)13.08±0.66	(4)1.38±0.10	(4)6.91±0.43	(3)1.36±0.13	(4)4.87±0.10	3.50
Icterus galbula	(7)17.95±0.37	(2)16.20, 17.40	1.96, 1.73	7.32, 8.34	(6)0.95±0.03	(7)5.59±0.11	3.65
Agelaius phoeniceus	2♀ 13.6, 15.2 6♂ 19.4±0.80	2♂ 18.0, 18.0	2♂ 1.39, 1.67	2♂ 7.22, 7.52	(7)0.85±0.19	(8)5.35±0.30	3.72
Leistes militaris	(3)20.44±0.34	(3)18.8±0.36	(3)1.83±0.09	(3)7.37±0.14	(12)0.59±0.02	(12)4.79±0.10	3.67
Sturnella magna (Panamá)	(14)19.56±0.36	(4)18.03±0.89	(4)1.82±0.10	(3)6.38±0.32	(11)0.33±0.02	(12)2.76±0.10	3.13
Sturnella magna (Florida)	(11)18.5±0.31	...	...	...	(7)0.33±0.02	2.88±0.05	3.13
THRAUPIDAE *Chlorophonia callophrys*	(6)18.3±0.54	...	...	...	(4)0.60±0.07	4.76±0.16	3.31

(*continued*)

TABLE I.—*continued*

	Body weight *grams*	Heart *% body weight*	Upper extremities *% body weight*	Lower extremities *% body weight*	Wings *cm.² per gram*	Aspect ratio
Tanagra elegantissima	2♀ 12.7, 16.0 2♂ 17.70, 14.39	(5)1.43±0.06	(1)26.74	(3)5.61±0.42	(4)4.33±0.34	1.86±0.02
Tanagra fulvicrissa	2♀ 13.21, 19.93	1.10, 1.11	...	6.1	3.95, 4.76	1.69, 1.74
Tanagra minuta	1♀ 10.93 1♂ 11.28	(2)1.25, 1.38	...	(1)4.66	(2)4.27, 4.4	1.80, 1.92
Tanagra luteicapilla	2♀ 10.92, 14.98 1♂ 11.75	(3)1.33±0.07	(3)23.90±0.39	(3)5.19±0.31	(3)3.99±0.42	(3)1.81±0.13
Tanagra lauta	2♀ 10.53, 11.00	(2)1.29, 1.45	...	5.27	(2)4.11, 4.29	1.86, 2.03
Tanagra imitans	4♂ 13.28±0.24	(5)1.25±0.03	21.83	(3)6.09±0.33	(6)4.90±0.23	(5)1.69±0.03
Tangara icterocephala	17♀ 22.5±0.37 24♂ 21.49±0.24	(26)1.09±0.03	(3)28.92±0.61	(4)6.42±0.23	8♀ 4.09±0.03 9♂ 4.70±0.01 P<0.01	(16)1.78±0.02
Tangara inornata	1♀ 19.36 1♂ 19.97	(2)1.07, 1.21	(2)23.72, 25.97	6.82, 6.92	4.66, 4.76	1.76, 1.82
Tangara larvata	6♀ 19.79±0.20 10♂ 17.84±0.36	(11)1.16±0.04	2♀ 25.51, 28.67 4♂ 29.87±0.63	(6)6.07±0.39	(6)4.67±0.18	(7)1.73±0.05
Tangara gyrola	11♀ 22.12±0.42 8♂ 21.49±0.35	(15)0.98±0.03	(7)28.86±1.21	(8)7.49±0.30	7♀ 4.10±0.13 P<0.05 5♂ 4.79±0.21	(12)1.68±0.03
Tangara guttata	6♀ 21.28±0.51 6♂ 19.58±0.12	(10)0.96±0.02	(5)25.75±1.39	(6)9.34±0.48	6♀ 3.45±0.10 P<0.01 6♂ 4.27±0.11	(12)1.67±0.02

	Upper extremities: Pectoral and sup. *% body weight*	Upper extremities: Pectoralis *% body weight*	Upper extremities: Supra-coracoideus *% body weight*	"Rest" *% body weight*	Tail *cm.² per gram*	Glide *cm.² per gram*	Buoyancy index
Tanagra elegantissima	(5)19.91±0.85	(1)19.19	(1)1.85	(1)6.70	1.81±0.07	5.56±0.46	3.27
Tanagra fulvicrissa	(2)18.2, 18.11	16.5	1.61	...	0.36, 0.61	4.66, 5.86	2.82
Tanagra minuta	(1)17.00	...	...	...	0.48, 0.55	5.22, 5.48	3.10
Tanagra luteicapilla	(3)18.15±0.12	(3)16.63±0.08	(3)1.51±0.05	(3)5.75±0.35	(3)0.69±0.13	(3)5.21±0.55	2.98
Tanagra lauta	(2)15.2, 16.9	...	...	...	0.43, 0.58	5.15, 5.36	3.05
Tanagra imitans	(5)17.63±0.53	(3)17.26±1.66	(3)1.66±0.12	5.4	(6)0.73±0.06	(6)6.21±0.30	3.44
Tangara icterocephala	8♀ 19.7±0.39 P<0.05 9♂ 20.9±0.22	(3)19.80±0.61	(3)1.85±0.09	(3)6.94±0.21	(17)0.84±0.04	(17)5.74±0.12	3.53
Tangara inornata	18.83, 19.65	16.2, 18.15	1.50, 1.63	5.89, 6.32	1.05, 1.14	6.46, 6.71	3.58
Tangara larvata	3♀ 20.15±0.94 6♂ 22.87±0.87	3♀ 17.84±1.18 4♂ 20.50±0.83	(7)1.34±0.21	(5)7.18±0.29	(5)1.01±0.07	(8)6.10±0.17	3.52
Tangara gyrola	(15)20.79±0.49	(8)17.14±0.92	(8)1.98±0.08	(7)7.80±0.48	(12)0.85±0.06	(15)5.72±0.17	3.53
Tangara guttata	(12)17.78±0.40	(5)17.19±0.56	(5)1.58±0.05	(5)7.18±0.73	(12)0.79±0.04	(12)5.15±0.20	3.23

	Body weight *grams*	Heart *% body weight*	extremities *% body weight*	extremities *% body weight*	*$cm.^2$ per gram*	Aspect ratio
Thraupis virens	14♀ 32.90±0.53 19♂ 31.95±0.53	(23)1.33±0.03	4♂ 31.32±0.85	(7)6.90±0.20	(20)4.08±0.08	(20)1.76±0.02
Thraupis palmarum	1♀ 37.81 7♂ 39.17±1.46	(5)1.31±0.10	(3)29.04±1.45	...	(4)3.90±0.25	(4)1.61±0.13
Ramphocelus dimidiatus	2♀ 30.1, 30.6 10♂ 30.14±0.64	(6)0.83±0.07	(3)22.23±2.97	(4)7.41±0.29	(4)4.02±0.07	(4)1.64±0.04
Ramphocelus passerinii	5♀ 30.66±1.14 9♂ 33.56±0.75	(10)0.98±0.04	(3)25.95±0.57	(4)8.41±0.62	(9)3.38±0.11	(9)1.55±0.01
Ramphocelus iceteronotus	3♀ 33.98±0.18 1♂ 37.67	(2)0.70, 0.87	22.56, 25.62	8.18, 8.76	3.85, 3.89	1.68, 1.57
Piranga rubra	6♀ 28.81±0.59 11♂ 30.43±1.05	(12)1.15±0.05	(5)26.50±0.51	(6)5.63±0.22	(13)4.46±0.10	(13)1.89±0.02
Piranga olivacea	2♂ 30.68 32.10	1.11, 1.22	(1)27.57	5.67	(1)5.22	2.00
Piranga leucoptera	6♀ 16.27±0.19 13♂ 17.03±0.26	(17)1.07±0.03	4♀ 23.74±1.18 4♂ 26.05±0.62	(7)6.03±0.16	(20)5.34±0.08	(17)1.61±0.02
Piranga ludoviciana	1♂ 31.2	0.93			4.31	1.18
Piranga bidentata	1♀ 34.52 7♂ 36.47±0.56	(8)1.02±0.04	(2)26.26, 27.97	6.2, 6.5	(6)4.13±0.12	(8)1.70±0.04
Habia rubica	4♀ 37.12±0.98 7♂ 35.01±0.71	4♀ 1.05±0.04 P<0.01 7♂ 1.46±0.12	♀ 23.51, 24.81 3♂ 27.57±3.57	(5)8.81±0.15	(12)4.01±0.12	(12)1.54±0.03

	Upper extremities						
	Pectoral and sup. *% body weight*	Pectoralis *% body weight*	Supra-coracoideus *% body weight*	"Rest" *% body weight*	Tail *$cm.^2$ per gram*	Glide *$cm.^2$ per gram*	Buoyancy index
Thraupis virens	10♀ 19.67±0.34 P<0.01 10♂ 22.13±0.47	3♀ 18.60±0.60 4♂ 20.35±1.30	3♀ 1.65±0.24 4♂ 2.02±0.10	3♀ 8.05±0.22 4♂ 7.61±0.85	(20)0.88±0.04	(20)5.49±0.03	3.61
Thraupis palmarum	(4)20.83±1.06	(3)19.25±0.70	(3)1.72±0.02	(3)8.06±0.44	(4)0.90±0.11	(4)4.71±0.71	3.64
Ramphocelus dimidiatus	(5)15.90±0.81	(4)14.88±0.97	(4)1.59±0.21	(4)5.68±1.11	(3)1.34±0.01	(4)6.00±0.20	3.54
Ramphocelus passerinii	(9)18.26±0.65	(3)17.03±0.47	(3)1.91±0.12	(3)7.00±0.12	(9)1.12±0.04	(9)4.94±0.13	3.27
Ramphocelus iceteronotus	15.96, 17.42	14.27, 16.15	1.27, 1.69	6.60, 8.20	0.74, 1.24	5.04, 5.58	3.56
Piranga rubra	(7)19.05±0.22	(5)17.58±0.17	(5)1.74±0.07	(5)7.39±0.22	(11)1.14±0.04	(12)5.96±0.02	3.70
Piranga olivacea	20.09	18.25	1.84	7.50	1.14	4.46	4.06
Piranga leucoptera	6♀ 16.89±0.44 P<0.01 14♂ 18.71±0.30	3♀ 15.80±0.80 5♂ 16.83±0.57	3♀ 1.52±0.06 5♂ 1.60±0.12	3♀ 6.72±0.22 4♂ 7.44±0.23	(18)1.30±0.03	(15)7.05±0.10	3.73
Piranga ludoviciana	20.57	19.03	1.54		1.16	5.95	3.68
Piranga bidentata	(8)19.60±0.39	(3)17.05±0.75	(3)1.80±0.09	(4)6.60±0.02	(7)1.33±0.06	(8)5.82±0.15	3.69
Habia rubica	6♀ 16.81±0.62 7♂ 20.79±1.15	3♀ 16.36±1.62 5♂ 19.6±1.65	3♀ 1.61±0.16 5♂ 1.89±0.13	2♀ 6.89, 8.38 3♂ 7.33±0.86	(12)1.09±0.04	(12)5.64±0.20	3.64

(*continued*)

TABLE 1.—*continued*

	Body weight *grams*	Heart *% body weight*	Upper extremities *% body weight*	Lower extremities *% body weight*	Wings *cm.² per gram*	Aspect ratio
Habia fuscicauda	7♀ 38.05±0.82 11♂ 40.75±1.24	8♀ 0.74±0.04 P < 0.01 12♂ 0.84±0.03	3♀ 19.90±2.28 3♂ 26.00±2.08	(7)8.66±0.26	(13)4.65±0.14	(13)1.56±0.03
Tachyphonus rufus	5♀ 35.24±0.96 3♂ 35.53±1.31	(4)0.83±0.10	(3)25.56±2.04	(3)9.87±0.46	(3)3.93±0.07	(3)1.55±0.12
Tachyphonus luctuosus	3♀ 14.56±0.77 6♂ 15.55±0.91	(9)0.99±0.05	(4)21.02±1.38	(5)5.98±0.47	(7)5.36±0.19	(7)1.64±0.02
Eucometis penicillata	1♂ 30.86	(1)0.97	...	(1)7.25	4.78	1.67
Rhodinocichla rosea	3♀ 47.69±1.25 7♂ 50.09±0.42	(7)0.63±0.02	(4)25.09±0.94	(6)11.36±0.49	(6)2.96±0.10	(6)1.47±0.04
Chlorospingus ophthalmicus	4♀ 18.54±0.64 8♂ 21.14±0.36	(12)0.96±0.04	(4)19.32±0.75	(5)8.90±0.24	(11)4.07±0.09	(11)1.62±0.03
Chlorospingus pileatus	3♀ 17.9±0.43 3♂ 19.5±1.9	(5)1.07±0.06	...	7.95	(5)4.63±0.20	1.58±0.03
FRINGILLIDAE						
Saltator atriceps	2♂ 92.5, 96.74	0.82, 0.98	25.86, 25.97	7.90, 8.91	2.90, 2.99	1.50, 1.57
Saltator maximus	13♀ 49.07±0.82 17♂ 46.20±0.42	8♀ 1.23±0.05 P < 0.01 11♂ 1.57±0.07	4♀ 24.22±0.74 6♂ 28.65±0.74	(11)8.18±0.25	6♀ 3.57±0.08 P < 0.01 12♂ 4.04±0.05	(18)1.65±0.02
Saltator albicollis	8♀ 41.4±1.08 4♂ 40.64±1.79	(11)0.79±0.03	(5)22.17±0.52	(6)7.47±0.37	(8)3.67±0.14	(8)1.56±0.04

	Upper extremities						
	Pectoral and sup. *% body weight*	Pectoralis *% body weight*	Supra-coracoideus *% body weight*	"Rest" *% body weight*	Tail *cm.² per gram*	Glide *cm.² per gram*	Buoyancy index
Habia fuscicauda	7♀ 14.66±0.53 P < 0.01 9♂ 18.22±0.65	3♀ 13.03±1.37 3♂ 16.64±0.99	3♀ 1.29±0.10 3♂ 1.66±0.21	3♀ 5.58±1.37 3♂ 7.69±0.98	(12)1.41±0.04	(13)6.71±0.20	3.98
Tachyphonus rufus	(3)17.35±1.36	(3)15.62±1.25	(3)1.73±0.11	(3)8.21±0.74	(3)1.26±0.21	(3)5.28±0.32	3.57
Tachyphonus luctuosus	(9)16.11±0.44	(4)14.20±0.84	(4)1.33±0.05	(3)6.17±1.04	(7)1.49±0.10	(7)7.09±0.28	3.62
Eucometis penicillata	20.5	...	...	...	1.33	6.50	3.88
Rhodinocichla rosea	(4)17.17±0.49	(4)15.55±0.52	(4)1.87±0.10	(4)7.67±0.58	(4)1.27±0.05	(5)4.59±0.17	3.33
Chlorospingus ophthalmicus	(11)15.66±2.03	(5)12.42±0.43	(5)1.27±0.06	(4)5.39±0.23	(10)1.01±0.04	(11)5.55±0.13	3.32
Chlorospingus pileatus	(5)12.6±0.69	...	...	...	1.01±0.08	6.04±0.26	3.52
FRINGILLIDAE							
Saltator atriceps	18.03, 18.25	16.56, 16.70	1.47, 1.55	7.72, 7.83	0.74, 0.92	4.06, 4.24	3.66
Saltator maximus	7♀ 16.93±0.28 P < 0.01 11♂ 19.83±0.30	4♀ 15.05±0.36 7♂ 18.52±0.34	4♀ 1.61±0.07 7♂ 1.67±0.06	4♀ 7.56±0.34 6♂ 8.47±0.44	(20)1.23±0.04	6♀ 5.24±0.14 P < 0.01 12♂ 5.72±0.08	3.71
Saltator albicollis	(8)15.64±0.21	(5)14.54±0.26	(5)1.52±0.04	(5)6.11±0.48	(8)1.13±0.07	(8)5.22±0.11	3.57

	Body weight *grams*	Heart *% body weight*	extremities *% body weight*	extremities *% body weight*	*cm.² per gram*	Aspect ratio
Richmondena cardinalis floridana	3♀ 37.0±3.17 12♂ 38.0±0.50	(15)0.94±0.03	(4)29.51±1.16	(4)6.68±0.32	(9)3.80±0.11	(9)1.51±0.03
Richmondena cardinalis cardinalis	13♀ 43.2±0.66 19♂ 44.2±0.80	(12)1.21±0.09	(6)25.52±0.59	(6)6.66±0.29	(5)3.48±0.09	(6)1.59±0.03
Pheucticus tibialis	5♀ 61.1±0.85 7♂ 63.1±0.91	(7)1.03±0.04	26.21, 28.04	(3)7.15±0.21	(4)3.42±0.11	(5)1.79±0.01
Pheucticus ludovicianus	10♀ 44.91±0.49 14♂ 44.46±0.75	(19)1.10±0.02	4♀ 25.89±0.60 1♂ 30.50	(6)6.62±0.24	(18)3.55±0.04	(17)1.88±0.07
Cyanocompsa cyanoides	1♀ 32.06 3♂ 32.7±0.7	(2)0.95, 0.97	(1)28.52	(2)6.71, 6.87	(2)3.25, 4.34	(2)1.51, 2.00
Passerina cyanea	1♀ 14.0 8♂ 15.35±0.45	(7)1.38±0.07	27.84, 27.25	(3)5.43±0.20	(4)6.17±0.71	(3)1.78±0.06
Tiaris olivacea	8♀ 9.19±0.34 13♂ 8.81±0.16	(15)1.15±0.03	3♀ 20.58±1.74 5♂ 24.51±0.60	(9)7.65±0.43	(12)5.47±0.13	(10)1.61±0.01
Sporophila aurita	1♀ 10.19 11♂ 10.60±0.14	(8)1.19±0.06	(4)22.02±0.97	(5)5.63±0.41	(6)5.23±0.37	(6)1.58±0.06
Oryzoborus funereus	4♀ 12.42±0.95 7♂ 11.30±0.43	4♀ 1.04±0.05 4♂ 1.22±0.05	(7)22.67±0.46	(8)6.70±0.29	(5)5.59±0.02	(6)1.60±0.05
Volatinia jacarina	5♂ 9.01±0.26	(6)1.08±0.03	22.02	(3)7.86±0.57	(6)5.44±0.13	(6)1.52±0.02
Spinus xanthogaster	1♂ 13.12	1.59	27.70	5.18	4.99	2.00

	Upper extremities						
	Pectoral and sup. *% body weight*	Pectoralis *% body weight*	Supra-coracoideus *% body weight*	"Rest" *% body weight*	Tail *cm.² per gram*	Glide *cm.² per gram*	Buoyancy index
Richmondena cardinalis floridana	(10)18.46±0.89	(4)19.2±0.75	(4)2.01±0.10	(4)8.26±0.40	(9)1.54±0.22	(9)5.80±0.19	3.54
Richmondena cardinalis cardinalis	(6)18.32±0.41	(6)16.58±0.36	(6)1.74±0.11	(6)7.19±0.28	(5)1.35±0.23	(6)5.17±0.31	3.50
Pheucticus tibialis	(5)18.47±0.43	17.05, 18.6	1.62, 1.76	7.54, 7.68	(4)0.82±0.10	(4)4.59±0.08	3.68
Pheucticus ludovicianus	4♀ 18.26±0.25 10♂ 19.39±0.43	4♀ 16.68±0.25 1♂ 19.71	4♀ 1.61±0.04 1♂ 1.94	4♀ 7.61±0.36 1♂ 8.85	(17)0.95±0.07	(17)4.87±0.08	3.56
Cyanocompsa cyanoides	(2)17.12, 20.95	15.22, 19.00	1.90, 1.95	(1)7.57	(2)0.64, 1.24	(2)4.36, 6.10	...
Passerina cyanea	(3)20.96±0.03	19.2, 18.9	1.74, 2.03	6.9, 6.32	(3)1.77±0.18	(4)8.55±0.87	3.72
Tiaris olivacea	5♀ 15.95±0.66 7♂ 17.29±0.47	3♀ 13.88±0.52 5♂ 15.56±0.71	3♀ 1.42±0.16 5♂ 1.85±0.13	3♀ 5.28±1.22 5♂ 7.10±0.46	(12)1.34±0.07	(12)7.43±0.17	3.37
Sporophila aurita	(6)16.87±0.52	(5)15.17±0.60	(5)1.65±0.10	(4)5.41±0.46	(5)1.12±0.08	(6)7.10±0.27	3.39
Oryzoborus funereus	(8)16.37±0.48	(7)14.49±0.51	(7)1.78±0.07	(7)6.40±0.08	(6)1.45±0.06	(6)7.67±0.15	3.54
Volatinia jacarina	(6)15.10±0.42	14.4	1.83	5.79	(6)1.31±0.07	(6)7.44±0.21	3.36
Spinus xanthogaster	21.30	19.42	1.88	6.40	0.92	6.40	3.42

(continued)

TABLE 1.—*concluded*

	Body weight *grams*	Heart *% body weight*	Upper extremities *% body weight*	Lower extremities *% body weight*	Wings *cm.² per gram*	Aspect ratio
Spinus tristis	7♀ 12.8±0.5 9♂ 13.1±0.4	(3)1.70±0.06	(2)25.96, 28.33	3.77, 4.82	5.41, 5.79	1.96, 1.96
Pezopetes capitalis	1♀ 55.94 1♂ 55.83	(2)0.59, 0.62	...	16.80	(2)2.40, 2.74	1.41, 1.45
Pselliophorus tibialis	5♀ 30.1±0.60 7♂ 32.1±0.70	(11)0.81±0.04	(3)21.04±2.36	(4)11.69±0.65	(8)4.39±0.18	(7)1.48±0.03
Atlapetes brunnei-nucha	5♀ 38.88±1.50 3♂ 40.76±0.48	(5)0.82±0.06	...	11.6, 14.0	(5)2.98±0.10	(5)1.42±0.03
Atlapetes assimilis	1♀ 39.03 2♂ 38.9, 43.8	(3)0.84±0.01	(2)20.05, 23.21	12.08, 13.12	(3)3.09±0.11	(3)1.46±0.06
Atlapetes torquatus	3♀ 44.14±1.62 3♂ 43.58±3.38	(4)0.82±0.06	22.24, 22.42	(4)11.2±0.59	(5)3.06±0.20	(4)1.45±0.04
Atlapetes gutturalis	3♀ 36.84±1.24 8♂ 36.15±0.52	(11)0.88±0.04	17.82, 19.43	(4)13.11±0.55	(9)3.14±0.05	(9)1.50±0.03
Arremonops conirostris	10♀ 37.23±0.69 $P<0.01$ 7♂ 42.26±0.84	(10)0.85±0.04	(6)19.61±0.80	(6)12.97±0.63	(6)2.97±0.15	(6)1.51±0.07
Pipilo erythrophthalmus alleni	15♀ 38.0±0.90 26♂ 39.0±0.55	12♀ 0.83±0.03 $P<0.05$ 23♂ 0.94±0.04	4♀ 19.83±0.69 6♂ 22.72±0.75	(10)13.2±0.17	10♀ 2.68±0.11 13♂ 3.10±0.07 $P<0.01$	(23)1.53±0.02
Pipilo erythrophthalmus erythrophthalmus	3♀ 38.96±1.06 19♂ 42.17±0.48	(5)1.07±0.04	(4)24.58±0.66	(4)11.5±0.29	(4)2.86±0.14	(4)1.55±0.02

	Upper extremities: Pectoral and sup. *% body weight*	Upper extremities: Pectoralis *% body weight*	Upper extremities: Supra-coracoideus *% body weight*	"Rest" *% body weight*	Tail *cm.² per gram*	Glide *cm.² per gram*	Buoyancy index
Spinus tristis	19.78, 21.95	18.08, 20.5	1.45, 1.70	6.18, 6.38	0.99, 1.41	6.98, 8.02	3.63
Pezopetes capitalis	10.9, 13.4	...	...	...	0.73, 0.98	3.74, 3.83	3.13
Pselliophorus tibialis	(10)13.15±0.66	(3)12.59±1.83	(3)1.35±0.15	(3)7.09±0.42	(10)1.42±0.09	(10)6.06±0.20	3.72
Atlapetes brunnei-nucha	(5)14.57±0.47	12.95	1.70	...	(5)1.11±0.07	(5)4.40±0.11	3.19
Atlapetes assimilis	(3)15.16±1.01	(3)13.37±0.64	(3)1.79±0.03	(2)6.53, 7.13	(3)0.92±0.06	(3)4.45±0.09	3.28
Atlapetes torquatus	(4)15.26±0.69	14.05, 14.90	1.56, 1.92	5.78, 6.45	(5)0.82±0.08	(5)4.27±0.24	3.29
Atlapetes gutturalis	(10)13.23±0.28	(3)11.9±0.53	(3)1.39±0.01	5.44, 5.84	(8)1.27±0.08	(9)4.63±0.19	3.22
Arremonops conirostris	(7)14.49±0.37	(6)12.61±0.32	(6)1.68±0.03	(6)5.33±1.40	(6)0.60±0.09	(6)4.10±0.14	3.18
Pipilo erythrophthalmus alleni	(24)14.0±0.46	...	...	(10)6.18±0.15	10♀ 1.23±0.14 13♂ 1.45±0.10	10♀ 4.42±0.24 13♂ 5.17±0.12 $P<0.01$	3.09
Pipilo erythrophthalmus [illegible]	(4)18.04±0.50	(4)16.2±0.40	(3)1.63±0.20	(4)6.54±0.19	(4)1.05±0.06	(4)4.65±0.13	3.14

	Body weight *grams*	Heart *% body weight*	Upper extremities *% body weight*	Lower extremities *% body weight*	Wings *cm.² per gram*	Aspect ratio
Spizella pusilla	3♀ 13.1±0.52 12♂ 13.2±0.27	(11)1.28±0.03	(3)26.21±0.27	(3)5.50±0.40	(4)5.77±0.22	(3)1.68±0.04
Zonotrichia capensis	11♀ 19.96±0.49 15♂ 20.96±0.23	(21)0.86±0.03	(4)19.44±0.55	(5)11.32±0.54	(16)3.74±0.06	(16)1.63±0.02
Melospiza melodia	10♀ 20.32±0.34 23♂ 22.1±0.42	(8)1.15±0.06	(3)25.99±2.35	(3)9.68±0.56	(3)3.73±0.21	(3)1.59±0.03

	Upper extremities						
	Pectoral and sup. *% body weight*	Pectoralis *% body weight*	Supra-coracoideus *% body weight*	"Rest" *% body weight*	Tail *cm.² per gram*	Glide *cm.² per gram*	Buoyancy index
Spizella pusilla	(3)20.20±2.05	(3)18.27±1.88	(3)1.94±0.25	(3)6.00±0.33	(4)1.52±0.17	(4)8.22±0.36	3.52
Zonotrichia capensis	(16)14.88±0.42	(5)12.84±0.64	(5)1.55±0.09	(4)5.55±0.08	(16)0.83±0.03	(16)5.08±0.12	3.21
Melospiza melodia	(3)16.82±1.94	(3)15.1±1.73	(3)1.69±0.22	(3)5.84±1.03	1.08, 1.10	(3)5.72±0.31	3.20

TABLE 2.—*Seasonal variation of proportional weight of the heart*

Species	No.	January February Percent of body weight	No.	June Percent of body weight	Significance of difference
Anhinga anhinga ...	(8)	1.01±0.03	(7)	0.79±0.038	$P<0.01$
Ardea herodias	(5)	0.90±0.04	(5)	0.76±0.04	$P<0.05$
Eudocimus albus ...	(13)	1.12±0.03	(13)	0.97±0.03	$P<0.01$
Buteo lineatus	(7)	0.73±0.05	(7)	0.55±0.03	$P<0.01$
Aphelocoma coerulescens	(6)	1.07±0.03	(11)	0.92±0.03	$P<0.01$

TABLE 3.—*Muscles of the upper extremities* (percent of body weight)

Species	Total	Pectoralis	Supra-cora-coideus	Shoulder	Brachium	Forearm
Tinamus major	43.74	26.9	8.17	3.44	2.43	2.80
Pelecanus occidentalis	18.96	11.30	1.85	2.24	2.30	1.26
Phalacrocorax olivaceus	18.49	11.90	1.24	1.91	2.54	1.15
Anhinga anhinga	20.11	12.95	1.28	1.04	2.46	1.57
Ardea herodias	23.17	15.00	1.06	1.47	3.40	2.24
Heterocnus mexicanus	23.10	13.40	1.38	3.06	3.12	2.14
Ixobrychus exilis	14.06	8.32	1.57	1.25	1.77	1.15
Mycteria americana	27.25	18.35	1.44	2.77	2.23	2.45
Eudocimus albus	31.32	19.40	2.24	2.80	4.60	2.48
Aythya affinis	22.19	14.60	2.02	2.45	2.16	1.12
Coragyps atratus	26.11	15.10	0.81	2.49	4.65	2.48
Chondrohierax uncinatus	29.49	17.10	0.49	3.30	4.77	3.82
Caracara cheriway	22.53	14.30	0.62	1.60	3.81	2.19
Ortalis garrula	22.86	12.20	2.19	3.34	2.81	2.35
Coturnix coturnix japonica	25.17	15.36	5.58	1.90	1.59	0.74
Colinus virginianus	35.65	22.40	7.06	3.42	1.72	1.05
Odontophorus guttatus	27.31	16.25	5.74	2.05	1.80	1.47
Gallus gallus (White Leghorn)	16.56	8.78	3.50	1.61	1.44	1.23
Laterallus albigularis	11.21	6.91	0.75	1.66	1.35	0.58
Squatarola squatarola	26.87	19.60	2.35	1.64	2.11	1.16
Ereunetes mauri	21.76	16.60	2.35	1.13	0.84	0.84
Sterna hirundo	20.02	14.00	1.13	1.57	1.71	1.61
Thalasseus sandvicensis	18.74	12.80	1.09	1.37	1.88	1.57
Rynchops nigra	20.02	13.10	1.13	2.93	1.94	1.96
Columba livia	31.79	20.50	3.57	1.26	3.27	3.24
Columba speciosa	40.20	26.45	4.78	3.15	3.07	2.74
Crotophaga sulcirostris	20.70	12.50	0.97	1.60	3.15	2.45
Otus choliba	23.35	14.00	1.04	1.87	4.24	2.20
Megaceryle torquata	25.31	14.50	1.26	3,25	4,24	2.06
Chloroceryle aenea	22.24	14.75	2.00	1.60	2.83	1.06
Colaptes auratus	30.16	19.20	1.10	2.90	4.53	2.34
Melanerpes erythrocephalus	26.32	16.90	0.99	2.59	3.78	2.06
Synallaxis albescens	18.07	11.00	1.34	2.14	3.04	0.50
Muscivora tyrannus	33.45	23.60	2.29	2.76	3.29	1.51
Iridoprocne bicolor	23.46	16.20	1.04	2.49	2.45	1.29
Aphelocoma coerulescens	21.02	12.90	1.22	2.24	2.84	1.82
Mimus polyglottos	19.89	11.70	1.35	2.19	3.11	1.53
Mniotilta varia	29.35	16.80	1.55	4.46	6.61	
Parula americana	21.53	14.30	1.39	2.19	2.36	1.29
Agelaius phoeniceus	26.89	18.00	1.67	2.54	2.80	1.87
Richmondena cardinalis	32.04	21.00	2.08	2.85	4.14	1.97
Spizella passerina	26.61	18.30	1.63	2.06	2.97	1.62

TABLE 4.—*Muscles of the lower extremities* (percent of body weight)

Species	Total	Thigh	Leg
Tinamus major	13.14	7.36	5.78
Pelecanus occidentalis	5.71	3.37	2.42
Phalacrocorax olivaceus	11.30	3.95	5.93
Anhinga anhinga	8.72	4.36	4.36
Ardea herodias	12.00	5.79	6.28
Heterocnus mexicanus	12.20	6.31	5.88
Ixobrychus exilis	12.21	6.13	6.08
Mycteria americana	10.30	4.70	5.63
Eudocimus albus	8.48	4.65	2.72
Aythya affinis	5.20	2.78	2.42
Coragyps atratus	14.40	7.75	6.62
Chondrohierax uncinatus	7.50	4.36	3.14
Caracara cheriway	13.60	6.68	6.90
Ortalis garrula	20.10	10.60	9.40
Coturnix coturnix japonica	10.78	6.38	4.40
Colinus virginianus	13.20	7.43	5.77
Odontophorus guttatus	14.10	8.22	5.90
Gallus gallus (White Leghorn)	15.38	7.02	5.36
Laterallus albigularis	18.15	10.30	7.82
Squatarola squatarola	5.35	2.81	2.61
Ereunetes mauri	4.76	2.79	1.98
Sterna hirundo	2.63	1.52	1.11
Thalasseus sandvicensis	2.28	1.36	0.91
Rynchops nigra	2.46	1.41	1.04
Columba livia	6.38	3.39	2.55
Columba speciosa	4.78	2.73	1.97
Crotophaga sulcirostris	12.35	7.44	4.92
Otus choliba	8.83	3.34	5.49
Megaceryle torquata	2.95	2.10	0.86
Chloroceryle aenea	2.50	1.59	0.91
Colaptes auratus	7.25	4.60	2.66
Melanerpes erythrocephalus	6.04	3.11	2.93
Synallaxis albescens	10.20	5.01	5.15
Muscivora tyrannus	2.73	1.47	1.26
Iridoprocne bicolor	2.68	...	...
Aphelocoma coerulescens	14.50	6.87	7.57
Mimus polyglottos	10.80	5.29	5.50
Mniotilta varia	6.58	...	...
Parula americana	6.95	2.97	3.48
Agelaius phoeniceus	8.86	4.00	4.86
Richmondena cardinalis	7.14	3.67	3.47
Spizella passerina	6.14	3.15	2.99

TABLE 5.—*Comparative values of typical species*

Species	Body weight *grams*	Pectoralis plus supracoracoideus *% body weight*	Wings			Glide *cm² per gram of body*	Leg muscles *% body weight*	Heart *% body weight*
			cm.² per gram of body	Buoyancy index	Aspect ratio			
Campylopterus hemileucurus	11.85	31.75	3.67	2.91	2.63	6.71	1.17	2.10
Claravis pretiosa	72.20	30.20	2.58	3.28	1.82	3.71	4.65	1.31
Tinamus major	1140.0	30.00	0.95	3.31	1.44	1.16	12.80	0.20
Cotinga ridgwayi	55.00	25.30	3.22	3.50	1.92	4.18	6.00	1.17
Odontophorus guttatus	290.0	24.70	1.22	2.84	1.45	1.50	16.9	0.33
Trogon collaris	65.00	23.50	3.32	3.66	1.95	5.35	1.62	1.05
Stelgidopteryx ruficollis	14.50	21.40	7.54	4.30	2.40	9.69	1.60	1.61
Pyrrhura hoffmanni	84.00	21.30	2.85	3.53	2.18	3.87	5.60	1.43
Myiarchus tuberculifer	20.00	20.50	5.87	4.00	1.70	8.29	5.30	0.86
Melanerpes rubricapillus	52.00	18.8	4.12	3.92	1.92	4.77	5.70	1.22
Aythya affinis	575.00	18.20	0.81	2.60	2.84	1.06	7.00	0.89
Chloroceryle americana	35.50	16.80	3.31	3.31	2.24	4.43	2.92	1.24
Zonotrichia capensis	20.50	15.00	3.76	3.21	1.64	5.11	12.70	0.88
Butorides virescens	165.0	13.20	3.26	4.23	2.39	3.66	9.70	0.70
Podiceps dominicus	120.0	10.90	1.60	2.81	2.56	1.87	16.40	1.06
Aramides cajanea	385.0	9.10	1.65	3.48	1.62	1.87	24.40	0.54
Crotophaga sulcirostris	69.00	8.60	3.78	3.94	1.72	5.41	12.1	0.70