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QUESTIONING RELIABILITY OF BURSA DEPTH FOR AGE DETERMINATION IN RING-NECKED PHEASANTS

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We determined the bursa depth method to be unreliable, subjective, and problematic for age determination in ring-necked pheasants (*Phasianus colchicus*). Rigorous testing during a 6-year study in the Sutter Basin, California revealed that bursa depth was not distinctive for age class in wild pheasants, and we recommend abandoning the method. Results showed that bursa regression adequate to overlap adult standards for the method began in juveniles at 5 months-of-age, with closures starting at 6 months, and with regression completed before adulthood, demonstrating that shallow ($\leq$8 mm) and closed bursas are not distinctive for adults. Among known-age pheasants in the hunter bag, the method produced age misclassifications for 20% of adult males, 26% of adult females, 6% of juvenile males, and 10% of juvenile females. Probe measurements were 5-12 mm deeper in dead adults than in the same birds when alive 2-4 months earlier, a result of post-mortem loss of tissue elasticity. Closure was the most consistent bursa characteristic in wild, adult pheasants, occurring in 21% of males and 88% of females.

Key words: age determination, bursa of Fabricius, *Phasianus colchicus*, pheasant, technique

INTRODUCTION

Distinguishing young-of-the-year from adults can be important in wildlife research and management. Into at least the 1940s, pheasants (*Phasianus colchicus*) in mature plumage traditionally were aged by a combination of physical characteristics including (1) spur length, shape, and color; (2) strength of lower mandible; (3) length of tail feathers; and, (4) body size and weight (Stokes 1954). Some of these criteria were not applicable for age determination of hens or live male pheasants, and the process was subjective: the error rate for bagged males was approximately 4% for juveniles and 20% for adults, even when experienced biologists used these methods (Gates 1966).

Gower (1939) discussed the benefits of aging game birds by examining the bursa of Fabricius (hereafter, bursa), a small sac that opens into the cloaca on the dorsal side shortly inside the vent. In birds generally, the bursa opening is persistent in juveniles and closes

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with maturity, but bursas remain open in an appreciable proportion of adult pheasants. This led to the notion that bursa sacs that had regressed to relatively shallow depths also could be indicative of pheasant adulthood.

Space does not permit complete descriptions of the numerous investigations, conducted over > 30 years, of determining age class in pheasants by bursa depth that began with the pioneering work of Linduska (1943) and Buss (1943). Kirkpatrick (1944) examined bursae among pen-reared pheasants of different age classes and at different seasons, and reported that the bursa was present in all juveniles, but was absent in adult birds; hence, he concluded that an open bursa was indicative of juvenility, and could be used reliably to distinguish young from adults up through December of the year of hatching. Linduska (1943) and Buss (1943) both reported the presence of a bursa among some wild adult pheasants, and Kirkpatrick (1944) cautioned that the presence of a bursa could not be used reliably to separate juvenile from adult birds in the wild, but surmised that error associated with such determinations likely would be small. Davis (1947) reported a relationship between bursa depth, ossification of the skull, and maturity of gonads in a variety of avian species, and suggested depth of the bursa as a potentially meaningful method of determining relative age in wild birds.

Our review of the published results of this body of work revealed that no investigators had used adequate samples of known-age, wild pheasants that facilitated a direct comparison of bursa characteristics with established age. Nevertheless, a general consensus that bursa depth was the most reliable method developed to date for age determination evolved among pheasant biologists, even in the absence of agreement as to which bursa depth most reliably divided the adult and juvenile age classes. Indeed, pheasants having bursa depths of 4-10 mm comprised an overlap group both of adults with incomplete bursa regression, and juveniles with early, but advanced, regression. No definitive studies were made, however, to determine the age at which regression began or how it progressed in wild pheasants.

California Division of Fish and Game biologists participated in early evaluations of aging pheasants by bursa characteristics, and reported the bursa depth method to be unreliable when tested with small samples of known-age, wild pheasants. Indeed, 10 of 35 (29%) wild roosters of known age checked in the hunter bag had bursa measurements deep enough (11-19 mm) to be misclassified as juveniles (Harper et al. 1951). This discrepancy led to further evaluation of the basis for the technique in California's Sutter Basin (Mallette and Bechtel 1959), in which bursa characteristics in >14,000 wild pheasants of known age or age class were examined, but the resulting data were not analyzed and published at the time.

More recently, Larson and Taber (1980) concluded that bursa depth was the most reliable method then developed for distinguishing adult from juvenile age classes in pheasants, and recommended bursa depths of ≤8 mm as generally distinctive for adults. In a subsequent review, Dimmick and Pelton (1996) declared, without qualification, that depth of the bursa was a reliable method of separating juvenile from adult pheasants, citing Wishart (1969) as the authority. That citation was inappropriate, however, as Wishart (1969) presented no data or definitive information on aging by bursa characteristics. Further, no other studies or data on the bursa method more recent than Larsen and Taber's (1980) were cited by Dimick and Pelton (1996). As a result, Dimmick and Pelton (1996) presented no support for advancing the technique from the status of most reliable (Larsen and Taber 1980), to reliable without qualification. Whether this declaration of complete reliability was arbitrary or suffered from imprecise terminology is unclear, but Dimmick and Pelton (1996) presented nothing additional in support of such reliability.

Schroeder and Robb (2005) apparently reverted to the determination of Larson and Taber (1980) that bursa depth was the most reliable method, including their standard of ≤ 8 mm for distinguishing adult males, and Johnsgard's (1975) standard of ≤ 6 mm for adult females. Schroeder and Robb (2005) did not cite Dimmick and Pelton's (1996) declaration of complete reliability as a point of departure, but their failure to discuss the matter openly left the published record ambiguous and potentially confusing. That situation prompted us to recover and analyze the Sutter Basin bursa data, and our results add materially to information on bursa characteristics in wild ring-necked pheasants and the validity of bursa aging methods for that species.

Our study had two main objectives: (1) to examine bursa characteristics of known-age birds, both juvenile and adult, from a large-scale operation to sample and mark wild pheasants and, thereby, determine the ages at which bursa regression began and was completed; and, (2) to evaluate accuracy of the bursa depth method of age determination under field conditions by developing a sizeable pool of marked, known-age pheasants in the wild population that had the potential to be checked in hunter bags.

METHODS

Sutter Basin is located Sutter County in the southern Sacramento Valley (38.9°N, 121.7°W) and includes California's primary pheasant range. At the time our research was conducted, it was surrounded by water-filled channels of the Sacramento River and Tisdale and Sutter flood-bypasses, supported 27,520 ha (approximately 68,000 acres) of agricultural habitat, and was characterized by generally high-density pheasant populations of approximately 40 birds/ha (Hart et al. 1956, Mallette and Harper 1964).

We captured pheasants by spotlighting (Hart et al. 1956, Labisky 1968) during annual population sampling throughout Sutter Basin from July through September. In addition to examining bursas, we determined sex and age, and leg-banded all pheasants that we handled if they had not previously been marked. Juveniles too small to retain standard leg bands were marked with patagium clips. We processed all pheasants during each night of capture and released them in the field on site. During summer, juveniles typically were evident by their smaller size and immature plumage. Juvenility in sub-adults was ensured by examination of primary wing feathers, and all juveniles were further separated into age groups according to primary wing feather molt and replacement (Buss 1946).

We examined bursas in live pheasants captured annually in summer, and in dead birds in the hunter bag during the 16-day hunting seasons in the latter half of November. During the study, the seasonal bag of 10 roosters allowed 1 hen in lieu of a rooster, enabling legally taken hens to be checked in the bag. We used probes made from 8d finishing nails, with the points rounded and shanks marked at 2-mm intervals, to measure bursa depths. If the bursa was open, we inserted the probe and gently pressed it in until resistance was detected. The probe was then released sufficiently to rebound from tissue elasticity, with the depth at rest interpolated to the nearest mm. With apparently closed bursas, we tested the seam or scar of closure with the probe to ensure that was the case. In rare instances, we judged the bursa to have been ruptured by the probe or otherwise, and recorded no measurement in those cases.

Project personnel interviewed hunters as they left the field, and examined bursas of all pheasants in each bag. For marked birds, we collected bands or markers and recorded serial numbers along with the bursa measurements. These measurements were effectively blind as to the predetermined age of individual birds: the bag checkers had no knowledge of which pheasants had been banded as adults or juveniles, or as wild or pen-reared birds. All leg bands were standard aluminum bands used at the time by the Division of Fish and Game, and were identical except for the serial number. We also examined bursas in two groups of live, game-farm birds to assess state of bursa regression in known-age pheasants during winter and spring, when wild birds were not available.

We have used the term regression to describe bursas atrophying or degenerating, although some authors (e.g., Kirkpatrick 1944) have, instead, used the term involution to describe that process. We used “adult” or “mature” to describe pheasants ≥13 months old, despite pheasants entering the breeding population at approximately 8-10 months-of-age. As used here, a poult is a juvenile pheasant old enough to have lost all downy plumage, and a sub-adult is an older juvenile that has assumed full adult plumage. We used the conventional bursa method for the bursa depth system of determining age class in pheasants that previously had been declared reliable, and the standard of ≤8 mm in bursa depth considered distinctive for adults (Larson and Taber 1980, Schroder and Robb 2005). We used the term overlap for bursa depths ≤8 mm in juveniles, and ≥9 mm in adults.

We established a data bank of bursa characteristics for birds of known sex and age for all captured and marked pheasants that were handled ≥1 time. We used International Business Machine (IBM) punch-cards and data processing methods (the state of the art before development of modern electronic methods), and maintained a master card for each pheasant examined. All tabulations of data on these master cards were made with use of a mechanical card sorter; the few errors that we noted showed up as outliers that were readily detected, reconciled, and corrected.

In the analysis, we compared bursa closures and depths by sex and age groups of wild pheasants for (1) captured juveniles ranging from 6 through 16 weeks-of-age; n = 10,027; (2) known-age, previously captured juveniles in the hunter’s bag when they ranged from 5-7 months-of-age; n = 413); (3) summer-captured adults (≥1 year-of-age; n = 4,651); (4) previously captured adults of known age-class that were bagged in the same year (n = 224); (5) previously captured pheasants of known yearly age (bagged as adults ≥1 year after capture; n = 60); and, (6) known-age, pen-reared pheasants in game farms in winter and spring (n = 712).

RESULTS

Captured Juveniles

Wild pheasant poults had well-developed bursas (mean = 19 mm in depth) at 6 weeks-of-age (Table 1). Bursa depth generally increased with growth and age, but was less than proportional to gain in body size or mass, and with greater inconsistency in females. Apparently false bursa regression in both sexes occurred in the 9-13 week age classes, with minimum depths of 4-8 mm, and overlapped previously accepted standards for adult birds. However, development of the bursa resumed in older age classes, with minimum bursa depths of 12-13 mm at 16 weeks-of-age. Other than the apparent anomaly in the 9-13 week age groups (Figure 1), there was no evidence of bursa regression among the oldest juveniles, which were sub-adults of approximately 16 weeks-of-age (Figure1, Table 1).

Table 1. Bursa depth measurements (mm) from 10,027 summer-captured, wild, juvenile pheasants, by sex and age groups, Sutter Basin, Sutter County, California, 1952-1957.

Age (weeks)	Sex	*n*	Closed	Open	
				Range	Average
6	M	11	0	16-22	19
	F	6	0	19-21	19
7	M	171	0	13-28	19
	F	92	0	14-26	22
8	M	544	0	14-30	20
	F	509	0	12-34	20
9	M	842	0	4-33	22
	F	779	0	5-30	20
10-11	M	1,046	0	8-38	23
	F	1,033	0	10-33	26
12-13	M	1,005	0	8-38	24
	F	1,076	0	13-36	22
14-15	M	656	0	14-44	25
	F	699	0	10-46	24
16	M	699	0	13-40	27
	F	859	0	12-40	26
Totals	M	4,974	0		
	F	5,053	0		

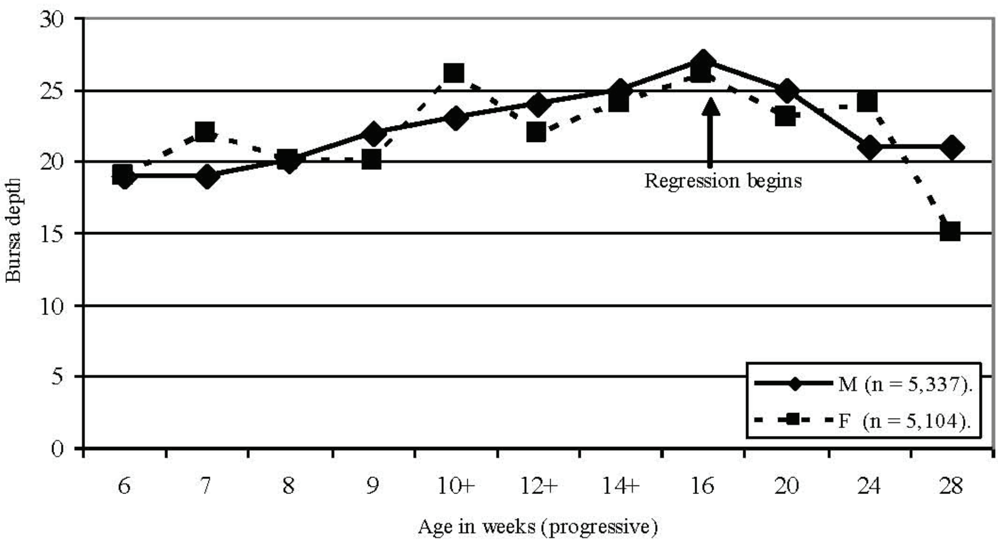

Figure 1. Average bursa depths (mm) of 10,440 wild, juvenile pheasants, by sex and weekly age groups, showing initiation of regression, Sutter Basin, Sutter County, California, 1952-1957.

Bagged Juveniles

Age composition of the juvenile bag, due to the span in hatching dates, was 5 months (9%), 6 months (51%), or 7 months (39%); 1% of the birds were of other ages. Bursa regression began in males in the 5th month, shortly after maximum development of the bursa was reached. Regression in both sexes progressed to overlap with adult standards in the 5-7 month age classes; bursa closures started at 6 months of age in females and at 7 months in males (Figure 1, Table 2). Of 413 known-age juveniles in the hunter bag, 22 (6%) males and 5 (10%) females exhibited regressed bursas and, as a result, were misclassified as adults. The mechanism of bursa closure among juveniles was unclear. These closures were recorded in juvenile age classes where other minimum bursa depths were 8-14 mm (Table 2), suggesting that closure did not necessarily result from progressive shortening of the sac, but could have been the result of the opening sealing over, or a combination of both.

Table 2. Bursa measurements (mm) from 413 hunter-bagged, wild, juvenile pheasants, by sex and age groups, Sutter Basin, Sutter County, California, 1952-1957.

Age (months)	Sex	*n*	Closed	Open	
				Range	Average
5	M	33	0	4-32	25
	F	6	0	18-31	23
6	M	190	0	2-34	21
	F	22	3	8-25	24
7	M	139	2	4-34	21
	F	22	1	14-26	15
8	M	0			
	F	1	0	8	8
Totals	M	362	2		
	F	51	4		

Older Juveniles

We were unable to examine bursas directly in juvenile, wild pheasants 8-12 months-of-age. Nevertheless, we observed no evidence of continuing bursa regression in these birds as they entered adulthood at ≥13 months-of-age, and we concluded that approximately 90% of bursa regression occurred at 8-12 months-of-age, mainly during winter and spring before they reached adulthood. It follows that the consequence of using bursa depth for age distinction during winter and spring will be commensurately and progressively higher error rates.

Captured Adults

The yearly age of wild, adult pheasants at initial capture was unknown, but Mallette and Harper (1964) reported that approximately 73% of such birds were 1 year old, and typically 13-15 months-of-age by summer, and that adults ≥2 years-of-age comprised 27%

of the adult population. We found no evidence of active bursa regression in pheasants ≥13 months-of-age.

The stage at which regression terminated varied considerably by sex and individual (Table 3). Bursa closure (i.e., completed regression) had been reached in 88% of adult females, compared to 21% of mature males. Among these adult males, the greatest proportion (79%) of bursas remained open, with most depths ranging from 1-5 mm. Among all adults, average depth of open bursas was 3 mm.

Open bursas, ranging from 25-29 mm in depth and supposedly indicative of juvenility, persisted in approximately 2% of the adult males and 6% of the adult females. Although proportionately small, this characteristic will cause a persistent error in misclassification of adults when using the conventional bursa method for age determination.

Table 3. Bursa measurements (mm) from 4,651 captured and 284 hunter-bagged wild, adult pheasants, by sex and age groups, Sutter Basin, Sutter County, California, 1952-1957.

Category	Sex	*n*	Closed	Open	
				Range	Average
Captured					
Age (Yrs.)					
Adult (Unk.)	M	1,080	226	1-25	3
	F	3,571	3,131	1-29	3
Bagged					
Age (Yrs.)					
Adult (Unk.)	M	134	27	1-40	8
	F	90	59	1-30	15
1.5	M	39	7	1-25	7
	F	9	8	4	4
2.5	M	7	2	2-27	10
	F	3	2	12	12
3.5	M	0			
	F	2	1	26	26
Bagged Subtotals	M	180	36		
	F	104	70		

Adults Bagged In Same Year

Age determinations of 20% of adult males and 26% of adult females obtained from hunter bags the year following hatching were in error; all of these adults had open bursas at the time of capture 2-4 months prior to being bagged. At time of capture when alive, average depth of open bursas in both sexes of these birds combined was 3 mm. However, a few months later and when dead, bursa depths in these birds averaged 8 mm in males and 15 mm in females, which resulted in a high proportion being misclassified as juveniles. Also, deepest measurement of bursas at time of capture was 29 mm, compared to 40 mm when dead (Table 3). The error rate for aging these adults with open bursas, when considered separately, was 26% for males and 68% for females.

We detected an apparent sampling anomaly among bagged adult females; 34% of these hens had open bursas, compared to 12% among summer-captured adult females, suggesting that the bagged hens were not a representative sample. We concluded that the sample of adult hens bagged and checked had been drawn disproportionately from the approximately 12% of the adult hen population that retained open bursas. This anomaly did not affect data or results from captured (live) adult females, but did influence some results for bagged adult females.

Later-bagged Adults

Yearly age was known for 60 pheasants that had been captured as juveniles and bagged by hunters1.5-3.5 years later. Among older dead males, 20% had closed bursas, with measured depths of open bursas averaging 8 mm, but with some as deep as 27 mm; 26% of those birds were misclassified as juveniles in the hunter-bag test. Among females, 78% had closed bursas, with the relatively few open bursas averaging 15 mm in depth (Table 3). Two birds bagged at approximately 4 years-of-age were females, one with a closed bursa and the other with a depth of 26 mm (Table 3). Although samples of the older birds were relatively small, they suggested no appreciable difference in bursa characteristics from the younger, bagged adults, including the deeper bursa measurements after death (Table 3).

We found no substantial difference in the average bursa depth of live adult male (n = 1,080) or female (n = 3,571) pheasants retaining open bursas, which averaged 3 mm in both sexes when captured in summer (Table 3), although maximum depth was slightly greater in females (29 mm) than in males (25 mm). This information did not support a need to use different standards for the sexes when aging live pheasants by this method, as used by Stokes (1954) and Johnsgard (1975). Further, probe-measured bursas were inaccurate in aging dead adult hens, which would not be corrected even by using the ≤6 mm standard.

Pen-reared Pheasants

Bursa regression in live, pen-reared pheasants of known-age during winter and spring was inconsistent, leading us to conclude that aging by the conventional bursa method was unreliable. We took bursa measurements from 126 known-age, pen-reared males in early February. Among 26 adults that were 20 months-of-age, bursa depths ranged from 0-7 mm, compared to 2-24 mm in 8-month-old juveniles. Using the ≤8 mm standard, 100% of adult roosters were classified correctly, but with substantial overlap and misclassification of juveniles. Bursa depth standards of <4 mm for adults, 4 mm as indeterminate, and >4 mm for juveniles were required to balance proportionately this overlap and produce accurate results overall. None of the 100 pen-reared roosters known to be 8 months old had closed bursas.

During April-June, we measured bursas of 580 pen-reared pheasants that were about 1 year old. Approximately 23% of 158 roosters and 16% of 422 hens had bursa depths ranging from 6 to 17 mm. These results indicated that appreciable proportions of both sexes of these new adults still had open bursas deep enough to classify them as juveniles by the conventional method.

DISCUSSION

Most bursa characteristics found in adult pheasants at any given time, and that have been considered distinctive for the age class, were based on regression of bursas that obviously took place earlier. To the best of our knowledge, however, the specificity of that time for wild pheasants had not been established. We concluded that bursa regression in pheasants is a juvenile phenomenon, and that nearly all pheasants undergo essentially complete bursa regression during approximately 5 through 12 months-of-age.

Bursa regression is largely completed in juvenility, but regressed bursas carried over from juvenile maturation into adulthood; thus, there are no bursa characteristics distinctive for either adult or juvenile age classes in pheasants. Nevertheless, that regressed bursas tend to be more consistently shallow (or are closed) in adults has been interpreted to be indicative for that age class (Kirkpatrick 1944). The adopted standard of ≤8 mm bursa depth, however, does not reliably distinguish adults from juveniles, but indicates only that such pheasants are ≥5 months old, and invalidates bursa depth as a totally reliable method for age determination in wild pheasants.

We made these determinations primarily by examining relationships between established ages, or age classes, with bursa characteristics in 14,678 captured, wild pheasants from approximately 6 weeks to 4 years of age. We further tested the method by using it to check 697 of these known-age pheasants in the hunter bag. The early bursa regression in juveniles 5-7 months old resulted in 6% of the males and 10% of the females in the bag being misclassified as adults when using bursa depths ≤8 mm as being distinctive for adults.

Accuracy of 90-95% when aging juveniles in the bag may be perceived as reasonable. Nevertheless, a relatively small mistake of this type can lead to erroneous conclusions if used to calculate recruitment or population composition (McCullough 1994), with the end result that the estimated ratio of juveniles to adults is biased substantially lower than reality.

Greater error resulted among known-age adults in the bag, including the misclassification of 20% of adult males and 26% of adult females overall as juveniles. Among these birds, open bursas were substantially deeper in adults when dead than when alive, a situation that we concluded was the result of post-mortem loss of tissue elasticity. Average depths of open bursas in live adults of both sexes at capture was 3 mm but, when measured dead in the bag 2-4 months later, was 8 mm for adult males and 15 mm for adult females. Moreover, the range of maximum depths in live adults was 25–29 mm, but 30-40 mm in dead adults (Table 3). Probe measurments generally were deeper in dead adults than in live adults, causing those birds to be misclassified as juveniles. This evidently was the same type of error that resulted in misclassification of 29% of adult males as juveniles by Harper et al. (1951).

We found no indication of active or continuing bursa regression in wild adults of any age from extensive sampling (n = 4,935), indicating that bursa regression was completed before juveniles entered adulthood at 12 months-of-age. We determined that approximately 6-10% of such regression took place at 5-7 months-of-age, and approximately 90% of bursa regression took place when birds were 8-12 months old during winter and spring. Similarly, Robertson (1958) concluded that bursa regression among juveniles was particularly rapid during winter and spring.

We further made a simple, common sense evaluation of the basic concept of aging pheasants by bursa depth or bursa regression, assuming that the accepted methodology is not qualified or limited to any particular time of year or age of pheasants (Schroder and Robb 2005). Pheasants traditionally are classed as juveniles through 12 months old, and then as adults upon entering the 13th month-of-age. Thus, by accepted standards, one day a pheasant is a juvenile and the next an adult, with no transitional period between age classes. Similarly, by the basic hypothesis for the bursa depth method, it necessarily follows that on these same days, pheasants first have a distinctively deep bursa (≥ 9 mm) and on the next day most have completely regressed and shallowed bursas, including a significant proportion of closures. We found no evidence that bursa regression occurs on such a timely, rapid, and regular basis. If not impossible, we consider this highly improbable as a biological process, and an illogical and unreasonable alternative to what we found from actual examination of wild pheasants in the field.

We determined that probe measuring produced significantly greater depth measurements from open bursas in dead pheasants than when alive, but only in adults. We found no reports of this apparent anomaly in published bursa investigations other than that reported by Harper et al. (1951) for adult males. We did, however, confirm a logical basis for the error. Linduska (1943) noted that the bursa sac was thick-walled and strong in juveniles, but essentially atrophied with regression in adulthood. Through that process, bursa sacs in adults became thin-walled and weak, difficult to distinguish from mesenteries, and so thin that the course of an inserted probe could be viewed through the sac walls (Linduska 1943). We confirmed Linduska's (1943) observations by limited dissection early in our study. It was evident to us that live tissues of regressed bursa sacs generally remained sufficiently elastic to rebound probes, and thereby yielded evidently representative measurements; the shallow average of 3 mm for depths of open bursas in live adults showed no evidence of appreciable inelastic stretching. We concluded that probe measurements of these weakend bursa sacs, a result of post-mortem loss of tissue elasticity in dead birds, resulted in excessive stretching without recovery, thereby yielding juvenile standards of depth. This situation was not detected by experienced probers, but became evident only after comparing average and maximum bursa depths in essentially the same groups of live (captured) and dead (bagged) adults (Table 3). We detected no evidence of this type of error among dead juveniles 5-7 months old, evidently because their bursa sacs were still thick-walled and strong.

Linduska (1943) and his co-workers originated the use of improvised probes, calibrated in 5-mm increments, to make the technique more feasible and broadly applicable than dissection (Gower1939), but the need for fine distinction of bursa depth was not realized at that time. Accepted standards of the bursa depth method evolved to where age classification in pheasants was determined by a difference of 1 mm in bursa depth (Larson and Taber 1980, Schroder and Robb 2005). Although actual depth of bursa sacs and age determination thereby required more precise measurement, bursa depths have been determined in practice by a blind measuring process not conducive to such exactness.

To the uninitiated, the bursa depth method may be perceived as objective, as it apparently is simply measuring the length of a physical characteristic between two points. However, only one point, the outer edge of the bursa opening, can be observed and the other must be detected by the degree of probe resistance. Although the bursa depth is the point at which the probe first bottoms in the sac, resistance develops and is detectable only with continued inward pressure on the probe after it bottoms. How quickly and consistently such resistance is detected, the amount of sac stretch and rebound, and the accuracy of the measurement depend mainly on (1) the strength and elasticity of the sac tissue; and, (2) the tactile sensitivity and technique of the investigator, which is a function of experience and judgment. The latter makes this a subjective process.

Developing a new method of measuring that would produce accurate depths of excessively weakened bursa sacs in dead adult pheasants may be possible, and perhaps useful to some extent. However, correcting for human error in probe measuring of bursas in dead adults does not salvage the bursa depth method as a meaningful technique. Effects of early and complete bursa regression in juveniles inherently flaw this method, so that bursa depth is not distinctive for age class in pheasants.

In the western hemisphere the ring-necked pheasant range extends across much of North America, from northern Mexico into Canada, in a wide range of conditions. These birds also vary in body size and mass according to the degree and nature of hybridization from the numerous sub-species that have been stocked (Allen 1956, Robertson 1997). Whether geographic variability is an appreciable factor in bursa characteristics of wild pheasants is unknown, and has not been evaluated fully. Accordingly, we do not imply that our results are necessarily representative of pheasants universally. Lacking other specific evidence, however, we consider the Sutter Basin results to be the most quantitative information available on bursa regression in wild pheasants. Nevertheless, before application elsewhere we recommend that our results be evaluated elsewhere to ensure the highest level of accuracy when determining age in pheasants.

Infallible accuracy is assured only through capture and marking of study birds in summer or early fall when age classes are evident or still can be determined by examination of primary wingfeathers (Buss 1946). If the bursa closure method is considered not to be appropriate for aging some dead pheasants, consideration should be given to reverting to dissection (Gower1939, Linduska 1943). Temporarily revisiting older methods could be productive and appropriate for some needs, or as a stopgap measure until a more reliable method is developed. Gate's (1966) test of those methods produced greater accuracy than we achieved with the conventional bursa method in our study, and Wishart's (1969) method of measuring proximal primaries, or similar methods, may warrant further evaluation or refinement.

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NOTE ADDED *IN PRESS*

The research described herein was conducted more than 50 years ago, with analysis and publication having been long-delayed. Continuity with the earlier California study (Harper et al. 1951) was provided by the senior author, who had ensured that the Sutter Basin research addressed the relevance of bursa depth for age determination in wild pheasants. He and coauthor Mallette participated directly in the Sutter Basin fieldwork, and both had first-hand knowledge of study conditions and methods that were required for analysis, evaluation, and interpretation of the data.

Chester M. Hart passed away in July 2009 following preliminary acceptance of this paper, and after working for 34 years with the Department of Fish and Game, and Robert D. Mallette, also a career CDFG employee, was not available to complete final revisions prior to publication. As a result, the tasks of completing those modifications and correcting page proofs were undertaken by the current editor, who is fully responsible for any errors or omissions remaining that, under different circumstances, would have been corrected by the authors.

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