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Title: Evolutionary History and Speciation of the Genus Tragopan

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John A. Crawford

A study of the phyletic relationships among five species of tragopans and an outgroup, the Blood Pheasant (Ithaginis cruentus), was conducted from 1987 to 1991. Biochemical, behavioral, and external morphologic characteristics were compared. A cladistic approach was used to compare the behavioral, biochemical, and external morphologic data collectively, as different phyletic relationships were obtained when each area of investigation was analyzed separately. Although unlike other pheasant species the genera Tragopan and Ithaginis molt their tail feathers centrifugally, study results did not indicate that these two groups were closely related. Based on a compilation of 25 characters, seven possible phylogenetic trees were generated. I rejected six of the seven trees based on current geographical distribution, morphology (size and complexity of lappet in males), behavior (wing coordination during the frontal display of male tragopans), and electrophoretic (number of unique alleles among the different species of tragopans) data. I accepted the tree that grouped Satyr and Western as closely related species and grouped Temminck's, Blyth's, and Cabot's tragopans together, with Temminck's and Cabot's being more closely related to each other than either was to Blyth's. I proposed that the prototype of tragopans probably had their origin in the eastern Himalayas. There were probably two major dispersal events; one population dispersed into central and south-east China and the Himalayas provided a corridor for the dispersal of a second population. Due to geological events in the Himalayas and China, these populations further split and eventually evolved into the extant forms.

EVOLUTIONARY HISTORY AND SPECIATION OF THE GENUS TRAGOPAN

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EVOLUTIONARY HISTORY AND SPECIATION OF THE GENUS *TRAGOPAN*

INTRODUCTION

The genus *Tragopan* (Family Phasianidae), endemic to Asia, consists of five species: Western (*T. melanocephalus*) (Gray), Satyr (*T. satyra*) (Linne), Temminck's (*T. temminckii*) (Gray), Blyth's (*T. blythi*) (Jerdon), and Cabot's (*T. caboti*) (Gould) (Peters 1934, Howard & Moore 1980). Three species of tragopans (Western, Satyr, and Blyth's) are distributed across the the Himalayas from Swat (northern Pakistan) in the west to the Chin Hills (northwestern Burma) in the east (Peters 1934, Delacour 1977, De Schauensee 1984). Cabot's Tragopan is restricted to southeastern China, and Temminck's Tragopan ranges extensively into central China (Peters 1934, De Schauensee 1984). Currently, the distributions of tragopans are allopatric with only minor zones of contact between Cabot's and Temminck's and between Blyth's and Satyr (Fig. 1) (Delacour 1977, Cheng Tso-Hsin 1980, Johnsgard 1986).

The relationship of tragopans to one another is obscure; it is not known which species are closely related to one another and which are more distant. Johnsgard (1986) proposed that tragopans represented two superspecies, consisting of Western, Satyr, and Temminck's as one group and Blyth's and Cabot's as a second. However, these observations were based primarily on the geographic distribution of tragopans and to a lesser extent, on plumage characteristics and ecological relationships. The extant species that may be closest to an ancestral form has not been determined. In areas where two species overlap in distribution (Cabot's and Temminck's tragopans in China and Satyr and Blyth's tragopans in eastern Bhutan), behavioral isolating mechanisms (e.g. differences in vocalization and courtship displays of males) have not been investigated. In order to establish phylogenetic relationships, data should be obtained from at least three areas of investigation: morphology, behavior, and biochemical analysis (Short 1967, Dobzhansky et al. 1977).

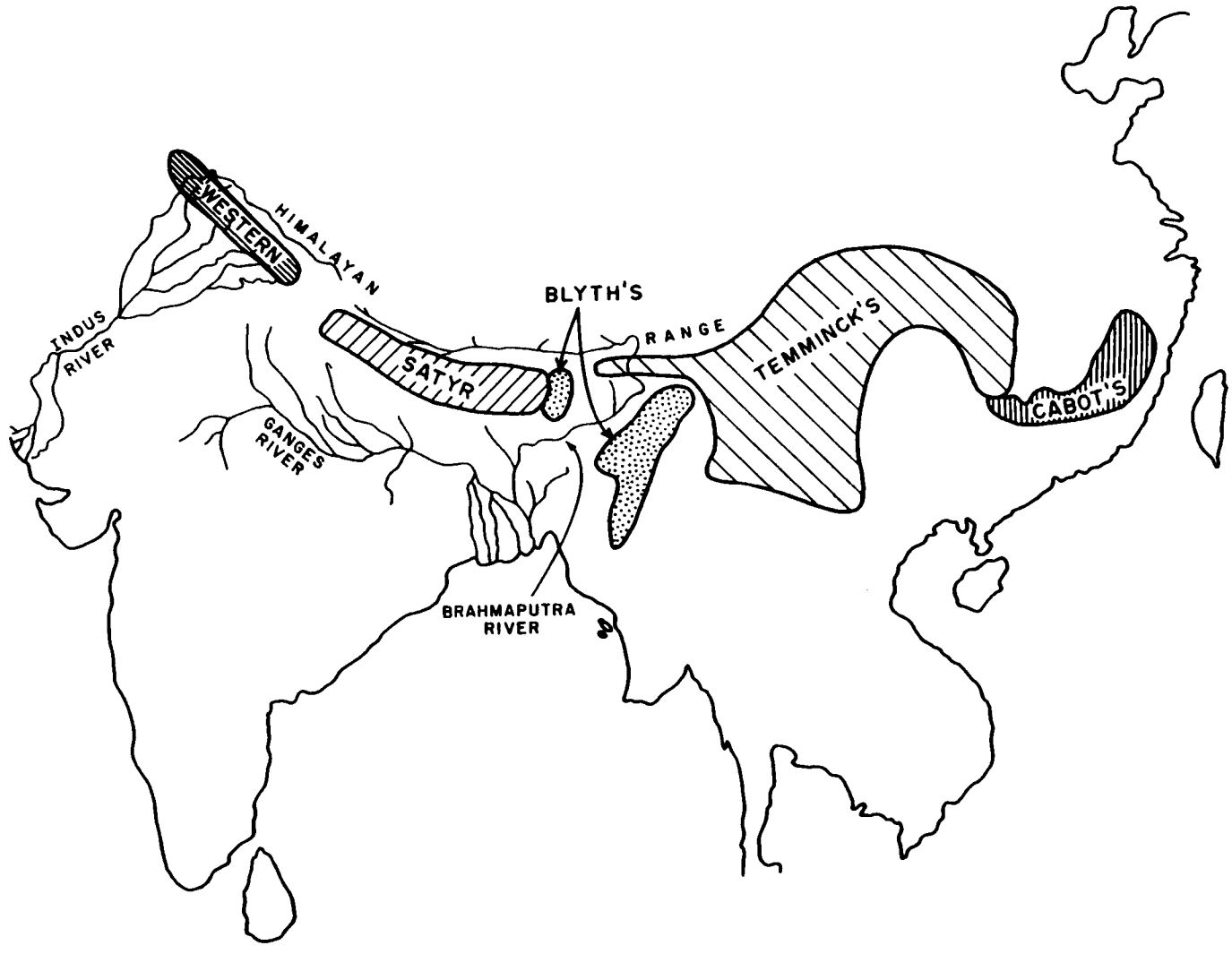

Fig. 1. Distribution of 5 species of tragopans with zones of contact (Modified from Johnsgard 1986).

A description of external morphology often was used in studies dealing with systematics (Short 1967, Jehl 1987, Goodman 1988). In tragopans, the sexes are dimorphic, and adult males of the different species are easily distinguished, which likely relates to sexual selection. However, yearlings/adult females, immature females, and chicks are often difficult to distinguish among species (Beebe 1914, Delacour 1977). Myologic, anatomic, and osteologic descriptions of species were used in taxonomic studies (Richards & Bock 1973, Strauch 1985), but not enough specimens of tragopans were available in collections to carry out these types of studies (Wood et al. 1982, Wood & Jenkinson 1984, Wood & Schnell 1986).

Behavior (especially in males) was used as a basis for defining inter- and intra-specific relationships in many species (Ficken & Ficken 1965, Johnsgard 1965, Johnsgard 1983a, Johnsgard 1986, Baptista & Trail 1988). Several authors suggested that courtship displays of males were important in maintaining species integrity (Hamerstrom & Hamerstrom 1960, Hjorth 1970, Johnsgard 1973). In tragopans, the courtship of males is highly ritualized and, compared with other behaviors, is less likely to change under artificial conditions (Delacour 1977, Rimlinger 1984, Johnsgard 1986). This behavior is observable in captivity and occurs over a restricted period of time.

Vocalization, another category of behavior, also was used to differentiate species and subspecies (Hjorth 1970, Baptista & Trail 1988, Dowsett & Dowsett 1988, Blockstein & Hardy 1989). Vocalizations emitted during courtship display and advertisement calls were important in maintaining species integrity, especially in areas where species were sympatric (Ficken & Ficken 1965, Sparling 1981, Sparling 1983).

Electrophoretic techniques were used in taxonomic work to study the proteins of blood, tissues, and egg-albumin (Baker et al. 1966, Gutierrez et al. 1983, Ellsworth et al. 1989, Lanyon & Lanyon 1989). These data revealed phylogenetic relationships at the generic, specific, subspecific, and population levels.

The goal of this research is to understand the evolutionary history of all species of tragopans. In order to understand evolution of any species, phyletic relationships need to be determined. The

following objective was addressed: To determine the systematic interrelationships among five species of tragopans with analysis of behavioral, biochemical, and external morphologic characteristics.

METHODS AND DATA ANALYSIS

Unlike other members of the family Phasianidae, tragopans and the Blood Pheasant (Ithaginis cruentus) molt their tail feathers centrifugally, and based on this characteristic, are considered closely related to one another (Beebe 1914, Delacour 1977, Johnsgard 1986). Thus, an outgroup comparison was made with the monotypic genus Ithaginis (Wiley 1981).

External Morphology

Taxonomic studies that dealt with plumage characteristics of males in sexually dimorphic species were usually unsuccessful at deriving species affinities among species. This result was attributed to sexual selection in males, which likely was the case with all species of tragopans. Because females of most avian species are under weak sexual selection pressure relative to males, female phenotypic characteristics tend to be more conservative (Weatherhead et al. 1984), and in tragopans, females, immatures, and chicks are difficult to distinguish among species.

Tragopans are unique among pheasants in that males have fleshy horns and lappets, which are prominent during the courtship display (Delacour 1977, Johnsgard 1986). Although the horns are colored blue in all tragopans, the size, coloration, and pattern of the lappets, and coloration of facial skin differ among species.

External measurements were useful in differentiating species and subspecies of birds (Jehl 1987, Goodman 1988, Storer 1989). Tragopans exhibit linear size differences in adult males, yearling males, and yearlings/adult females.

A total of 14 museums, which contained 99.9% of all tragopans and Blood Pheasant in North America, were visited from 1987 to 1991. In addition, live specimens were examined at zoos and private collections for descriptions of the coloration and pattern of the lappets and facial skin of male tragopans. Because no Western

Tragopans were in captivity during my study, the soft-part descriptions were limited to museum specimens and published information. The following five age and sex categories for all species of tragopans (except for immature Western Tragopans for which there were no specimens available) and four age and sex categories for Blood Pheasant were identified:

Chick-The plumage pattern and coloration of the following characters were noted: crown, forehead, back, upper wing coverts, throat, breast, and belly (Short 1967, Johnsgard 1973). To reduce subjective descriptions of tone colors, a standardized color guide applied in systematic studies (Johnson & Johnson 1985, Strauch 1985, Troy 1985) with numbers assigned to colors (Smithe 1974, Smithe 1975, Smithe 1981) was used.

Immature-Plumage coloration of the crown, back, rump, upper wing coverts, rectrices, throat, breast, belly, and crissum were recorded.

Yearling/Adult Female-All aspects of plumage description were identical to those recorded for immatures. In addition, the following external measurements were taken for the yearling/adult female category: wing length (chord), tarsus length, bill height (at anterior end of nostrils) and bill width (at anterior end of nostrils). All external measurements were recorded to the nearest 0.1 mm with digital calipers. Because it was not possible to measure tail length (central rectrices) without damaging specimens, this information was obtained from published data (Delacour 1977).

Yearling Male-The above-mentioned measurements were recorded, excluding tail length.

Adult Male-Measurements as described under yearling/adult female category were taken for adult males. Measurements of tail length were obtained from published data (Delacour 1977). The following coloration, size, and pattern characteristics of the facial skin and lappets for the six species were also noted: (a) coloration of facial skin, (b) size of lappet, (c) color of the center of lappet, (d) pattern of outer edge of lappet, (e) presence or absence of pattern on lappet, and (f) number of wedges or leaf-like patterns on lappet.

An attempt was made to construct frequency distributions of

plumage coloration for each body region among the five species of tragopans and Blood Pheasant for similarities and dissimilarities among the three age categories (Johnson & Johnson 1985, Troy 1985, Jehl 1987). Quantitative data obtained from external measurements were analyzed with univariate and multivariate statistics with the SAS (1985) computer program. Univariate analyses included normal probability plots (to determine if data were normally distributed), Analysis of Variance (ANOVA) (to determine if there was a significant difference among the different species based on a given parameter), and Student Neuman-Keuls mean separation test (to determine if species could be separated into groups for any given parameter based on their means). Quantitative data obtained from four external measurements were normally distributed (Appendix 1) for all age and sex categories of tragopans and Blood Pheasant. Multivariate analyses included Multivariate Analysis of Variance (MANOVA) (to determine if there was a significant difference among the different species based on all parameters) and Discriminant Function Analysis (DFA) (to determine if species or groups of species could be separated in multivariate space into distinct groups). A p-value of 0.10 was considered significant for all analyses (Snedecor & Cochran 1980).

Behavior

Courtship Display

Courtship displays of four species of tragopans, which consisted of two types- lateral and frontal (Delacour 1977, Rimlinger 1984, Johnsgard 1986), were observed under captive conditions. These displays were highly stereotyped and complex, and were used to compare different species of tragopans. Additional courtship/territorial displays were also noted. Approximately 20 hours of these behavioral observations were videotaped from 1989 to 1991.

The components of the lateral and frontal displays of male tragopans were analyzed and were compared among four species. Specifically the presence/absence of the following components was noted for lateral displays: (a) head arched towards the ground, (b)

side-stepping towards a female, (c) pecking at ground or object, (d) compressed body (Rimlinger 1984, Johnsgard 1986). In addition, the position and extent of the wing nearest the female and whether a male walked completely around a female or only made half-turns were noted. For frontal displays, the following data were recorded: (a) head bobbing/peering over object, (b) erection of horns and full expansion of lappet, (c) fanning of tail, (d) proximity of wings to body during wing flapping, (e) synchronization of wing flapping with calling, (f) wing flapping synchronization with other body movements, (g) voice emitted during display, (h) rearing of bird after climax followed by a hissing sound, (i) display ended with a rush towards the female, (j) kicking after climax (Rimlinger 1984, Johnsgard 1986).

Because Western Tragopans were not available in captivity, the courtship displays of this species were not observed. Unfortunately, there was no published account of the displays of this species to allow for a comparative study of all five species of tragopans. Also, no courtship displays of the Blood Pheasant were observed. However, there was published information on the lateral display of this species which was used for an outgroup comparison.

Vocalization

Advertisement/courtship calls and clicking sounds produced by males during the frontal display of four species of tragopans were recorded at five private collections and one zoo from 1988 to 1991. Additional recordings were provided by other researchers. Recordings of the courtship/advertisement calls of Western Tragopans were obtained in Pakistan in 1990. Because frontal displays were not observed in Western Tragopans, clicking sounds were not recorded. No courtship/advertisement call(s) were identified in the literature for Blood Pheasant (Grahame 1976, Delacour 1977, Johnsgard 1986) and none was recorded. Thus, no quantitative comparisons of advertisement/courtship calls were made between tragopans and the outgroup. However, a qualitative comparison (audio and visual from spectrographs) was made of three different types of calls of the Blood Pheasant with the vocal repertoire of tragopans. Four different types

of calls were recorded in tragopans which consisted of the following: (a) courtship/advertisement calls by males during the breeding season, (b) an alarm call uttered only by males, (c) an alarm call emitted by both sexes, and (d) clicking sounds produced by males during the frontal display.

Recordings of the courtship/advertisement calls of male tragopans of all species and the clicking sounds emitted during the frontal display of four species were reproduced on spectrographs. The following parameters, which were used by other researchers (Hjorth 1970, Sparling 1983, James 1985, Dowsett & Dowsett 1988), were measured for the advertisement/courtship calls: (a) number of notes per sequence, (b) note duration (sec), (c) internote interval (sec), (d) lowest frequency (hz), (e) highest frequency (hz), and (f) total time of call (sec). For the clicking segments of the frontal display, the following parameters were measured: (a) total number of clicks/display, (b) highest number of group(s) of click(s), (c) lowest number of group(s) of click(s), (d) highest frequency (hz), and (e) total time of clicking segment (sec). Comparisons of the different parameters were analyzed with univariate and multivariate statistics. Univariate statistics included normal probability plots, Student Neuman-Keuls mean separation test, and ANOVA. Quantitative data obtained from all vocal parameters were normally distributed for tragopans (Appendices 2 & 3). Multivariate analyses included MANOVA and DFA. A p-value of 0.10 was considered significant for all analyses (Snedecor & Cochran 1980).

Biochemical Analysis

Blood and tissue samples from the liver, heart, eye, and pectoral muscles were obtained from private aviculturists and a zoo for four species of tragopans. Blood and tissue were analyzed for protein polymorphism by hydrolyzed starch-gel electrophoresis (Smithies 1955, Avise 1974). Blood samples provided poor resolution with electrophoresis. Consequently, only tissues were examined for 44 proteins (Appendix 4). No blood or tissue samples were obtained from the Western Tragopan and Blood Pheasant.

Numerical Cladistic Analysis

A total of 25 characters that were dissimilar among the five species of tragopans and Blood Pheasant were chosen. For quantitative morphological and vocalization (courtship calls and clicks) measurements, only those variables that differentiated tragopans into two or more groups by the Student Neuman-Keuls mean separation test were used. Each character was assigned a score of 0, 1, 2, or 3. Missing data or where data were inappropriate, e.g. the Blood Pheasant lacks a lappet, were assigned a score of 9. The Blood Pheasant was designated as the outgroup. The characters and character states were as follows: (1) tail length (adult males & females, respectively)-Blood (160-180 mm, 130-160 mm)=0, Cabot's, Temminck's, and Blyth's (<230 mm, <180 mm)=1, Satyr and Western (>230 mm, >190 mm)=2, (2) tarsus length (adult males)-Blood=0, Cabot's and Temminck's=1, Satyr, Blyth's, and Western=2, (3) wing length (adult males)-Satyr=0, Temminck's, Blyth's, Cabot's, Western, and Blood=1, (4) pattern of outer edge of lappet (adult males)-plain (Blyth's)=0, leaf-like (Satyr & Western)=1, wedges (Temminck's & Cabot's)=2, absent (Blood)=9, (5) color of the center of lappet (adult males)-orange-yellow (Blyth's & Cabot's)=0, purplish-blue (Satyr, Western & Temminck's)=1, absent (Blood)=9, (6) color of facial skin (adult males)-red (Blood & Western)=0, orange-yellow (Blyth's & Cabot's)=1, blue (Temminck's & Satyr)=2, (7) size of lappet (adult males)-small (Blyth's <7.5 cm)=0, medium (Western & Satyr 7.5-12.5 cm)=1, large (Temminck's & Cabot's >12.5 cm)=2, absent (Blood)=9, (8) plumage (adult females/yearlings)-grayish to brown (Blood)=0, grayish (Western)=1, brownish (Satyr, Temminck's, Cabot's, & Blyth's)=2, (9) lowest frequency of courtship call (adult males)-Cabot's (150 hz)=0, Satyr, Temminck's, and Blyth's (200 hz)=1, Western (400 hz)=2, Blood (absent)=9, (10) highest frequency of courtship call (adult males)-Cabot's=0, Satyr and Blyth's=1, Western=2, Temminck's=3, Blood=9, (11) note duration of courtship call (adult males)-Cabot's (<0.5 secs)=0, Satyr, Temminck's, Blyth's, and Western (>0.5 secs)=1, Blood (absent)=9, (12) note interval of courtship call (adult males)-Cabot's (0.9 secs)=0, Satyr, Blyth's, Temminck's, and Western (>0.9 secs)=1,

Blood (absent)=9, (13) number of repetitions of call notes (adult males)-Western=0, Blyth's, Cabot's, Temminck's, and Satyr=1, Blood (absent)=9, (14) total time of courtship call (adult males)-Western=0, Blyth's, Satyr, and Temminck's=1, Cabot's=2, Blood (absent)=9, (15) total number of clicks (adult males)-Temminck's=0, Satyr and Cabot's=1, Blyth's=2, Blood and Western (absent/missing)=9, (16) highest number of clicks (adult males)-Blyth's (1)=0, Satyr and Temminck's (1-2)=1, Cabot's (>2)=2, Blood and Western (absent/missing)=9, (17) lowest number of clicks (adult males)-Satyr, Temminck's, and Blyth's (1)=0, Cabot's (2)=1, Blood and Western (absent/missing)=9, (18) total time of clicks (adult males)-Temminck's=0, Cabot's, Satyr, and Blyth's =1, Blood and Western (absent/missing)=9, (19) wing position during frontal display (adult males)-wings outstretched (Cabot's)=0, wings bent (Satyr, Temminck's, & Blyth's)=1, absent/missing (Blood & Western)=9, (20) wing coordination during frontal display (adult males)-poor (Blyth's)=0, good (Satyr, Temminck's, & Cabot's)=1, absent/missing (Blood & Western)=9, (21) presence or absence of arched posture during lateral display (adult males)-head not arched (Blyth's & Cabot's)=0, head arched (Satyr & Temminck's)=1, absent/missing (Blood & Western)=9, and proteins (22) IDH-allele a (Cabot's, Satyr, & Blyth's)=0, allele b (Temminck's)=1, absent/missing (Blood & Western)=9, (23) ACO-allele a (Cabot's)=0, allele b (Satyr, Temminck's, & Blyth's)=1, missing/absent (Blood & Western)=9, (24) FUMH-allele a (Cabot's, Temminck's, & Blyth's)=0, alllele b (Satyr)=1, missing/absent (Western & Blood)=9, (25) PEP-LT-allele a (Cabot's, Temminck's, & Blyth's)=0, allele b (Satyr)=1, absent/missing (Western & Blood)=9. All data were entered in a matrix format into the cladistic computer program 'Phylogenetic Analysis using Parsimony' (PAUP) (version 2.4) to generate phylogenetic trees (Swofford 1985).

Of the several numerical methods available for inferring phylogenies from character data, methods based on the principle of parsimony (e.g. PAUP) are the most widely used (Swofford & Olsen 1990). In general, parsimony methods select trees that minimize the total tree length i.e. the number of evolutionary "steps" (transformations from one character state to another) necessary to explain a given set of

data. According to the principle of parsimony, ad hoc hypotheses of homoplasy (parallelism, reversal, convergence) are minimized. The consistency index for a given tree is the measure of the relative amount of homoplasy in the data (Cracraft 1985). Hence, an index of 1.00 indicates that the characters of a tree have shown no reversals, convergence, or parallel changes.

RESULTS

External Morphology

Plumage-Plumage pattern and coloration of seven (chick) or nine (immature and yearling/adult female) body regions were noted for five species of tragopans and Blood Pheasant (Appendix 5). Sample sizes for the three age categories were as follows: chick-Cabot's (n=7), Satyr (n=6), Temminck's (n=5), Blyth's (n=4), Western (n=1), Blood (n=14); immature-Cabot's (n=3), Satyr (n=6), Temminck's (n=6), Blyth's (n=3), Western (n=0), Blood (n=7); yearling/adult female-Cabot's (n=12), Satyr (n=20), Temminck's (n=59), Blyth's (n=20), Western (n=5), Blood (n=132). Because of extreme intra-specific variation in plumage coloration and pattern, it was not possible to construct frequency histograms for each body region for any age category for a comparison of all species of tragopans and Blood Pheasant. Therefore, no individual species or groups of species were identified. Only yearling/adult female Western Tragopans were identified from the other four species by its grayer coloration (Appendix 5). All age categories of Blood Pheasant were, however, easily differentiated from tragopans.

External Measurements-A total of 512 specimens, which consisted of tragopans (n=276) and Blood Pheasant (n=236) was examined.

Adult males-Sample sizes by species were as follows: Cabot's (n=24), Satyr (n=24), Temminck's (n=54), Blyth's (n=16), Western (n=14), and Blood (n=150). There was a significant difference (ANOVA) among tragopans (n=132) and Blood Pheasant (n=150) for bill width ($p=0.10$), bill height ($p=0.03$), tarsus length ($p=0.0001$), and wing chord ($p=0.001$). Also, there was a significant difference (MANOVA) for all variables combined ($p=0.0001$). Therefore, all variables were analyzed by DFA. Because of overlap in size, no species of tragopans formed unique groups. Blood Pheasant, however, were easily separated by size from all species of tragopans (Fig. 2). A comparison of tail lengths indicated that tragopans formed two groups- long-tailed and short-tailed birds (Appendix 1). Based on data from Delacour (1977), the long-tailed group (>230 mm) consisted of Satyr and Western

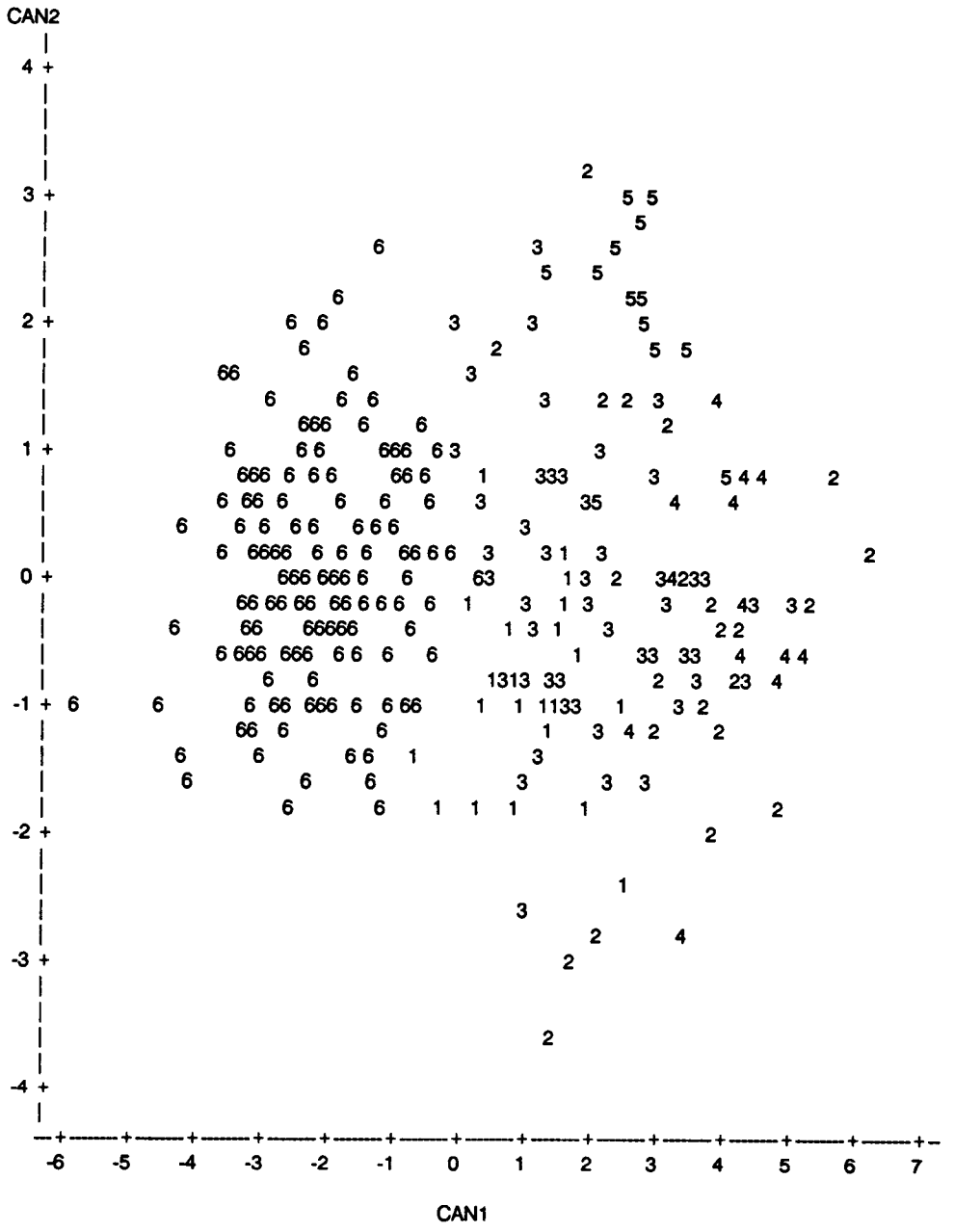

Fig. 2. A plot of canonical scores of 4 external measurements in adult males of 5 species of tragopans and Blood Pheasant. Species coding is as follows: 1=Cabot's, 2=Satyr, 3=Temminck's, 4=Blyth's, 5=Western, 6=Blood Pheasant.
NOTE: 178 observations had missing values and 35 observations are hidden.

tragopans and the short-tailed (<230 mm) tragopans included Blyth's, Cabot's, and Temminck's. Blood pheasant formed a third group (160-180 mm) (Appendix 1).

Yearling males-Sample sizes by tragopan species were as follows: Cabot's (n=4), Satyr (n=8), Temminck's (n=21), Blyth's (n=3), and Western (n=5). There was a significant difference (ANOVA) among tragopans (n=41) for the variables of bill width (p=0.01), bill height (p=0.03), tarsus length (p=0.001), and wing chord (p=0.1) and a significant difference for all variables combined (MANOVA,p=0.0001). No single species of tragopan or group of species separated by itself from the other species (Fig. 3).

Yearlings/adult females-Sample sizes for the different species were as follows: Cabot's (n=14), Satyr (n=19), Temminck's (n=49), Blyth's (n=17), Western (n=4), and Blood (n=86). There was a significant difference (ANOVA) among tragopans (n=103) and Blood Pheasant (n=86) for bill width (p=0.06), bill height (p=0.08), tarsus length (p=0.0001), and wing chord (p=0.10). There was a significant difference for all variables combined (MANOVA,p=0.0001). Blood Pheasants were easily separated from the five species of tragopans (Fig. 4). Because of overlap in mensural measurements among tragopans, no single species or group of species separated from other species of tragopans. As in adult male tragopans, adult females/yearlings formed two groups based on tail length (Delacour 1977). The longer tailed species (>190 mm) included Satyr and Western and the shorter tailed group (<180 mm) consisted of Temminck's, Blyth's, and Cabot's tragopans (Appendix 1). Blood Pheasant comprised a third group (130-160 mm).

Coloration/pattern of Facial Skin & Lappets-Twenty-eight live specimens of four species of tragopans and the Blood Pheasant, and three museum specimens (Western) were examined. Coloration of facial skin ranged from red (Blood Pheasant & Western) to orange-yellow (Blyth's & Cabot's) to blue (Temminck's & Satyr) (Table 1). The coloration of the center of the lappet was the same color as the facial skin except in Western Tragopans. Blood Pheasants lacked a lappet (Table 1). The size of the lappet differed from species-to-species but

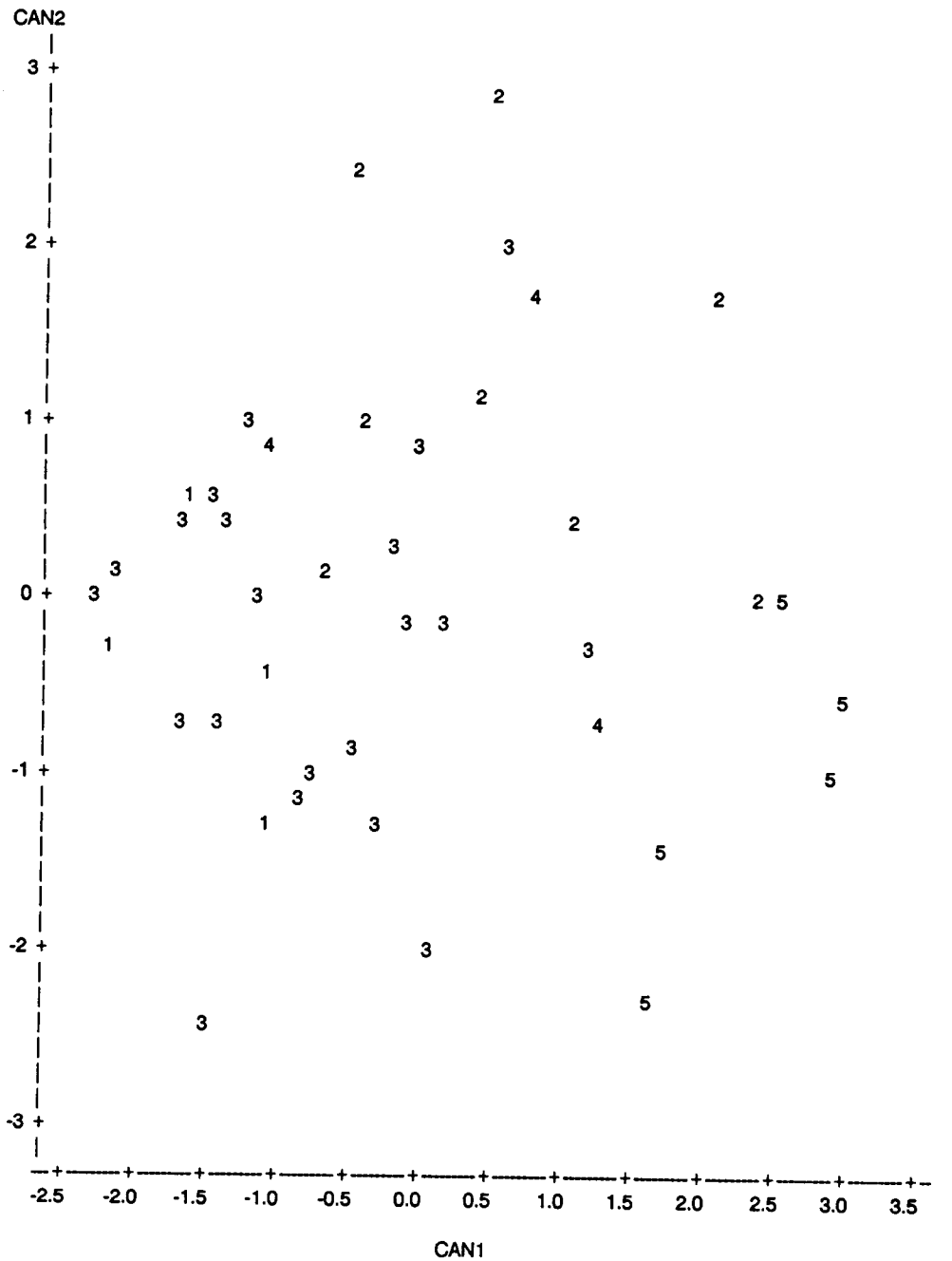

Fig. 3. A plot of canonical scores of 4 external measurements in yearling males of 5 species of tragopans. Species coding is as follows: 1=Cabot's, 2=Satyr, 3=Temminck's, 4=Blyth's, 5=Western. *NOTE*: 23 observations had missing values.

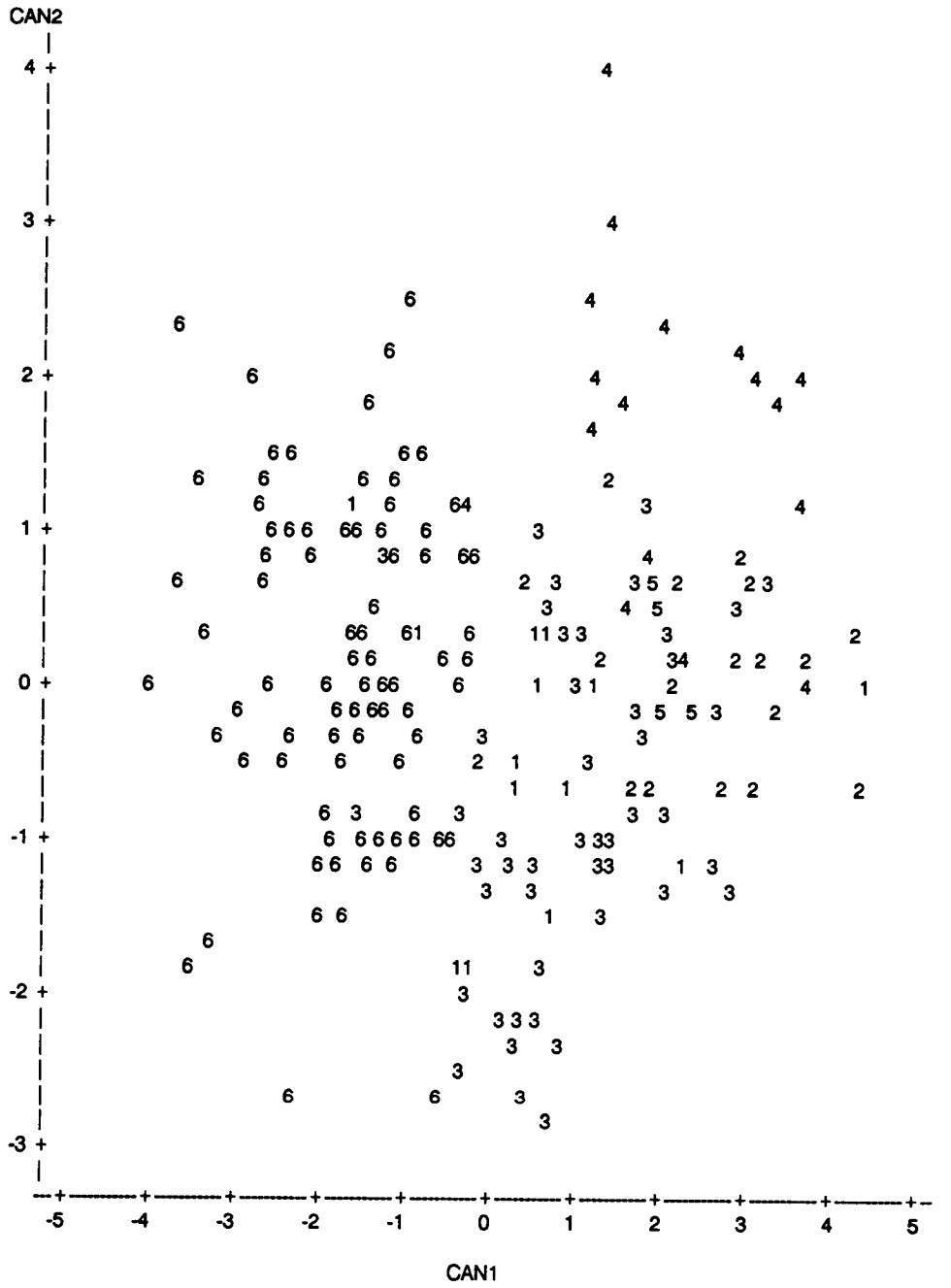

Fig. 4. A plot of canonical scores of 4 external measurements in adult females/yearlings of 5 species of tragopans and Blood Pheasant. Species coding is as follows: 1=Cabot's, 2=Satyr, 3=Temminck's, 4=Blyth's, 5=Western, 6=Blood Pheasant.
NOTE: 87 observations had missing values and 7 observations are hidden.

Table 1. Facial coloration and size, pattern, and coloration of lappets in males of 5 species of tragopans and Blood Pheasant.

Species	n	Facial skin coloration	Lappet				
			Size (cm)	Center color	Outer edge pattern	Presence/ absence of pattern	No. of leaf-like pattern/ wedges
Cabot's	7	orange	large (>12.5)	orange	wedges	present	8-9
Satyr	5	blue	medium (7.5-12.5)	blue	leaf-like	present	4-5
Temminck's	8	blue	large (>12.5)	blue	wedges	present	8-9
Blyth's	5	yellow	small (<7.5)	yellow	absent	absent	absent
Western	3	red	medium (7.5-12.5)	purple	leaf-like	present	4-5
Blood	3	red	absent	absent	absent	absent	absent

was easily separated into three categories-small (<7.5 cm, Blyth's), medium (7.5-12.5 cm, Satyr & Western), and large (>12.5 cm, Temminck's & Cabot's). There was also a progression in the complexity of the pattern on the outer edges of the lappet (Table 1). Blyth's Tragopans had no pattern, whereas Satyr and Western tragopans had 4-5 leaf-like markings. The most complex lappets occurred in Temminck's and Cabot's tragopans and consisted of 8-9 crimson wedges (Table 1).

Behavior

Courtship Display

Lateral displays were similar among the four observed species of tragopans and consisted of the following components: the wing was drooped towards the female, the body was compressed, the males made half-turns towards the female, and all males exhibited side-stepping towards the female. Also, all males pecked at the ground or an object, a behavior that may be a precursor to the tidbitting display found in many species of pheasants (Johnsgard 1986). The arched posture of the male, however, was only observed in Temminck's and Satyr tragopans. The lateral display of the Blood Pheasant reportedly differed from tragopans in that the male was reported to make complete turns around the female (Beebe 1918-22). Also, many parts of the lateral display were not reported in the Blood Pheasant.

The components of the frontal display were much more complex than those of the lateral display and consisted of the following stages: peering and head bobbing behind an object e.g. rock or tree stump, erection of horns and expansion of lappet, fanning of tail, synchronization of wing flapping with clicking sounds, coordination of wing flapping, wings were flapped either in an outstretched position or in a bent position, production of clicking sounds, rearing of the bird after the climax accompanied by hissing, rushing towards the female, and kicking after the climax. The number of completed segments of the frontal display that were videotaped differed among tragopans and were as follows: 30 (Cabot's,n=5 males), 20 (Satyr,n=4 males), 26 (Temminck's,n=4 males), and 3 (Blyth's,n=1 male). All components of

the frontal display were very similar among the species of tragopans. However, there were two differences that separated one species of tragopan from the others. The wing coordination during the flapping phase of the frontal display of Blyth's Tragopan was poor in comparison with the other three species. Unlike most species of tragopans, Cabot's Tragopan held its wings in an outstretched position during the flapping phase. The frontal display has not been observed in the Blood Pheasant (Johnsgard 1986).

Three other courtship/territorial displays that were observed during this research included a flight display as a male either flew up to or down from its perch in an exaggerated manner, a wing whir as the bird was stationary on the ground or perch, and a lappet display during which a male would drop its lappet by vigorously shaking it from under its throat. All of these displays were generally performed in the company of females, although some may have been in response to other male tragopans or other species of pheasants. None of these displays have been noted in the virtually unstudied Blood Pheasant.

Vocalization

A total of 180 advertisement/courtship calls of five species of tragopans were recorded and produced on spectrographs during the course of this study (Fig. 5). Sample sizes by species were as follows: Cabot's (n=19), Satyr (n=50), Temminck's (n=30), Blyth's (n=39), and Western (n=42). There was a significant difference ($p=0.0001$) among tragopans for all vocal parameters (ANOVA & MANOVA). There was a significant difference (DFA) for lowest frequency ($p=0.0001$), highest frequency ($p=0.0001$), note duration ($p=0.0001$), and note interval ($p=0.001$). Because the variables number of notes per sequence ($p=0.46$) and total time of call ($p=0.41$) were not significant, these variables were dropped from further analyses. A plot of the canonical scores revealed that tragopans separated into three groups (Fig. 6). Western and Cabot's separated each into their own group, whereas Blyth's, Satyr, and Temminck's formed a single group.

A total of 86 recordings of the clicking sounds produced during the frontal display were obtained for four species of tragopans (Fig.

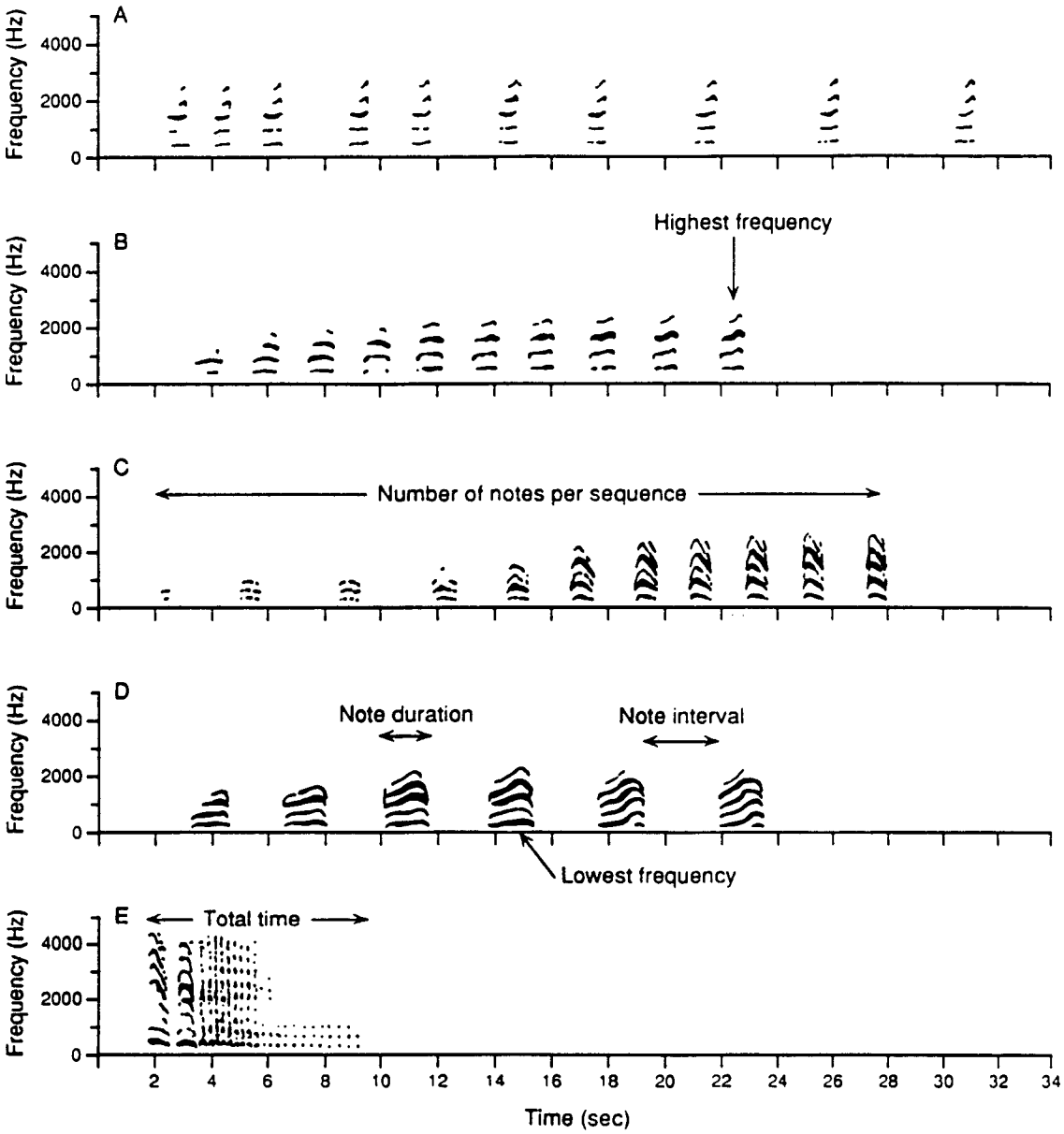

Fig. 5. Courtship/advertisement call in males of 5 species of tragopans. Top to bottom-A=Western, B=Satyr, C=Temminck's, D=Blyth's, E=Cabot's.

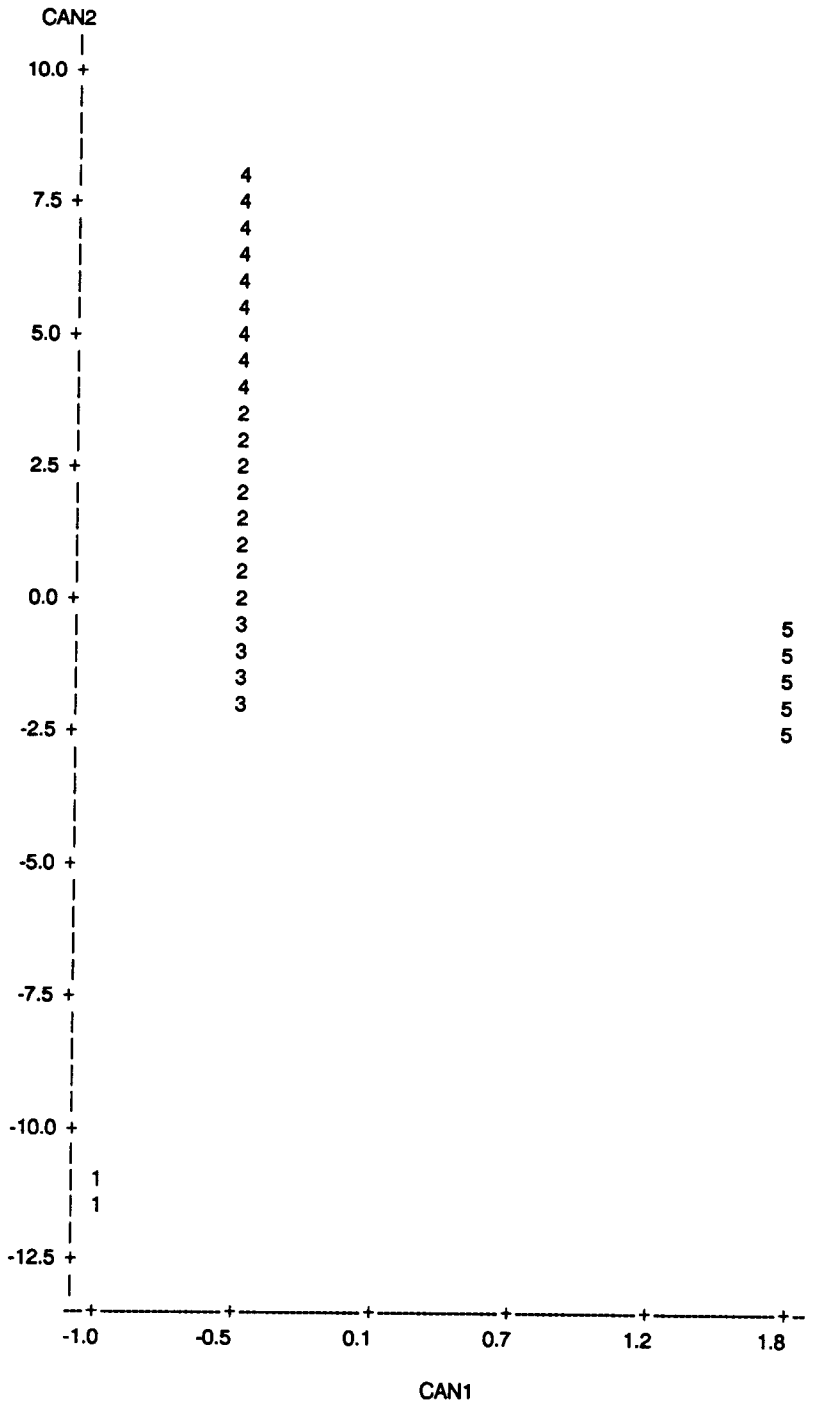

Fig. 6. A plot of canonical scores of 4 vocal parameters of the courtship/advertisement calls in males of 5 species of tragopans. Species coding is as follows: 1=Cabot's, 2=Satyr, 3=Temminck's, 4=Blyth's, 5=Western.
NOTE: 152 observations are hidden.

7). Sample sizes were as follows: Cabot's (n=29), Satyr (n=27), Temminck's (n=27), and Blyth's (n=3). There was a significant difference (p=0.0001) among tragopans (ANOVA) for four variables excluding highest frequency (p=0.79), which was removed from further analyses. The variables lowest number of group(s) of click(s) (p=0.0001), total number of clicks/display (p=0.0001), and highest number of group(s) of click(s) (p=0.001) were all significant (DFA). The variable of total time of clicking segment was not significant (p=0.49) and was dropped from further analyses. A plot of canonical scores indicated a similar grouping of species as obtained from the advertisement/courtship calls-Satyr, Temminck's, and Blyth's formed a single group, whereas Cabot's formed a separate group (Fig. 8). A qualitative comparison of three different types of calls (n=1) of Blood Pheasant (Fig. 9) with the vocal repertoire of tragopans (Figs. 5,7 & 10) indicated that they were very different.

Biochemical Analysis

Tissues from the liver, heart, eye, and pectoral muscles from 20 birds of four species of tragopans were examined for 44 proteins. Resolution was obtained for 36 proteins encoded by 62 presumptive loci (Appendix 4). Sample sizes for the different species of tragopans were as follows: Cabot's (n=7), Satyr (n=5), Temminck's (n=4), and Blyth's (n=4). Of the 62 loci identified, only four were polymorphic (ACO-1, FUMH-1, IDH-1, PEP-LT-2). Unique allele(s) occurred in Cabot's (ACO-1), Temminck's (IDH-1), and Satyr (PEP-LT-2 & FUMH-1) tragopans. No unique allele was found in Blyth's Tragopans.

Numerical Cladistic Analysis

All 25 characters defined for five species of tragopans and Blood Pheasant were used for a cladistic analysis with PAUP. Seven possible phylogenetic trees were generated with the computer program (Figs. 11 & 12). All trees had a branch length of 37 and a high consistency index of 0.919. For four of the seven phylogenetic trees,

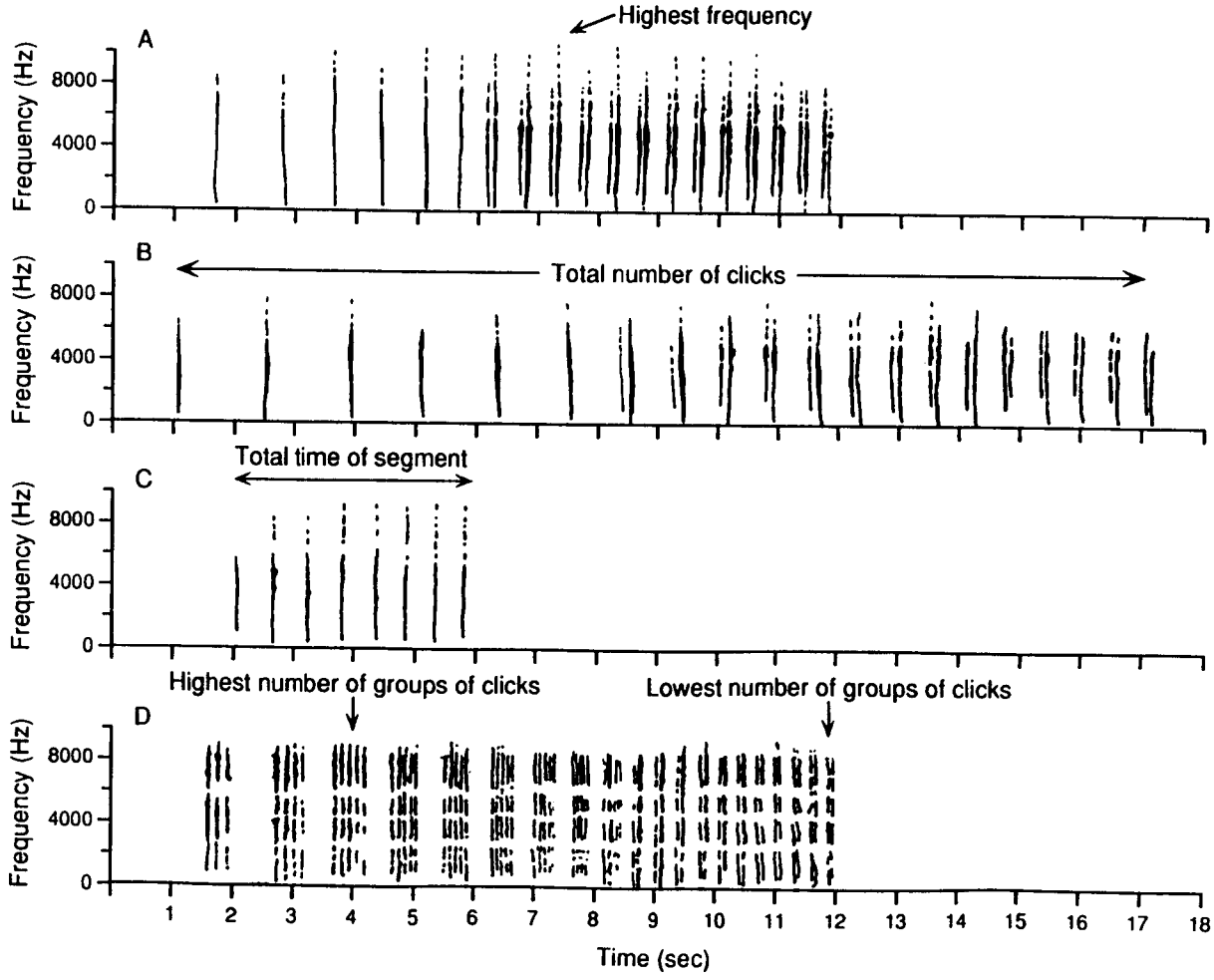

Fig. 7. Clicking sounds produced by males during the frontal display in 4 species of tragopans. Top to bottom-A=Satyr, B=Temminck's, C=Blyth's, D=Cabot's.

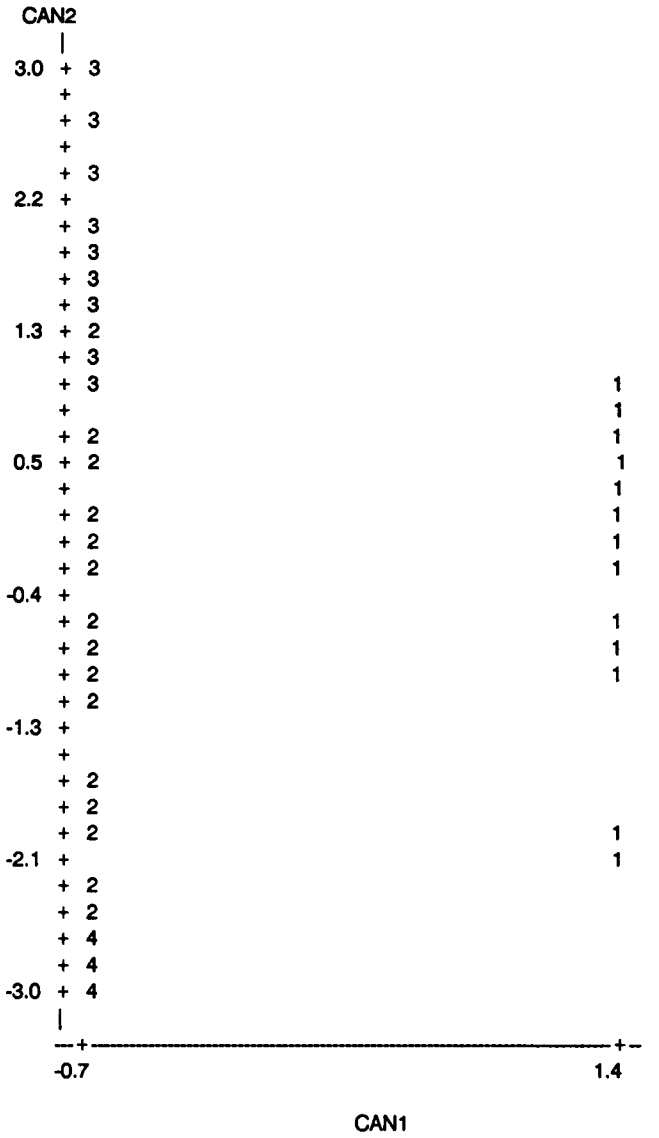

Fig. 8. A plot of canonical scores of 3 vocal parameters of the clicking sound produced by males of 4 species of tragopans during the frontal display. Species coding is as follows: 1=Cabot's, 2=Satyr, 3=Temminck's, 4=Blyth's.
NOTE: 46 observations are hidden.

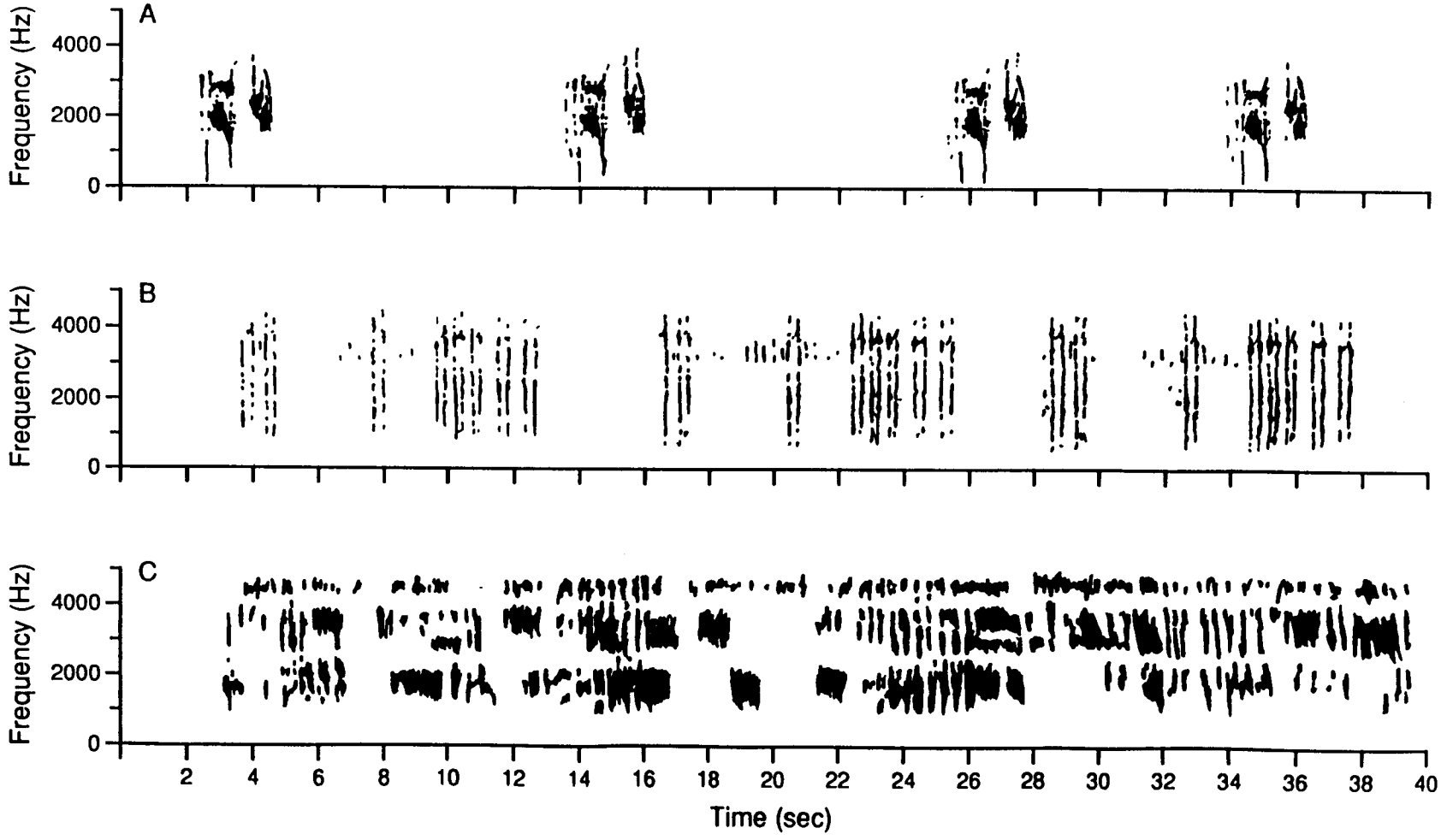

Fig. 9. Three different types of calls of the Blood Pheasant.

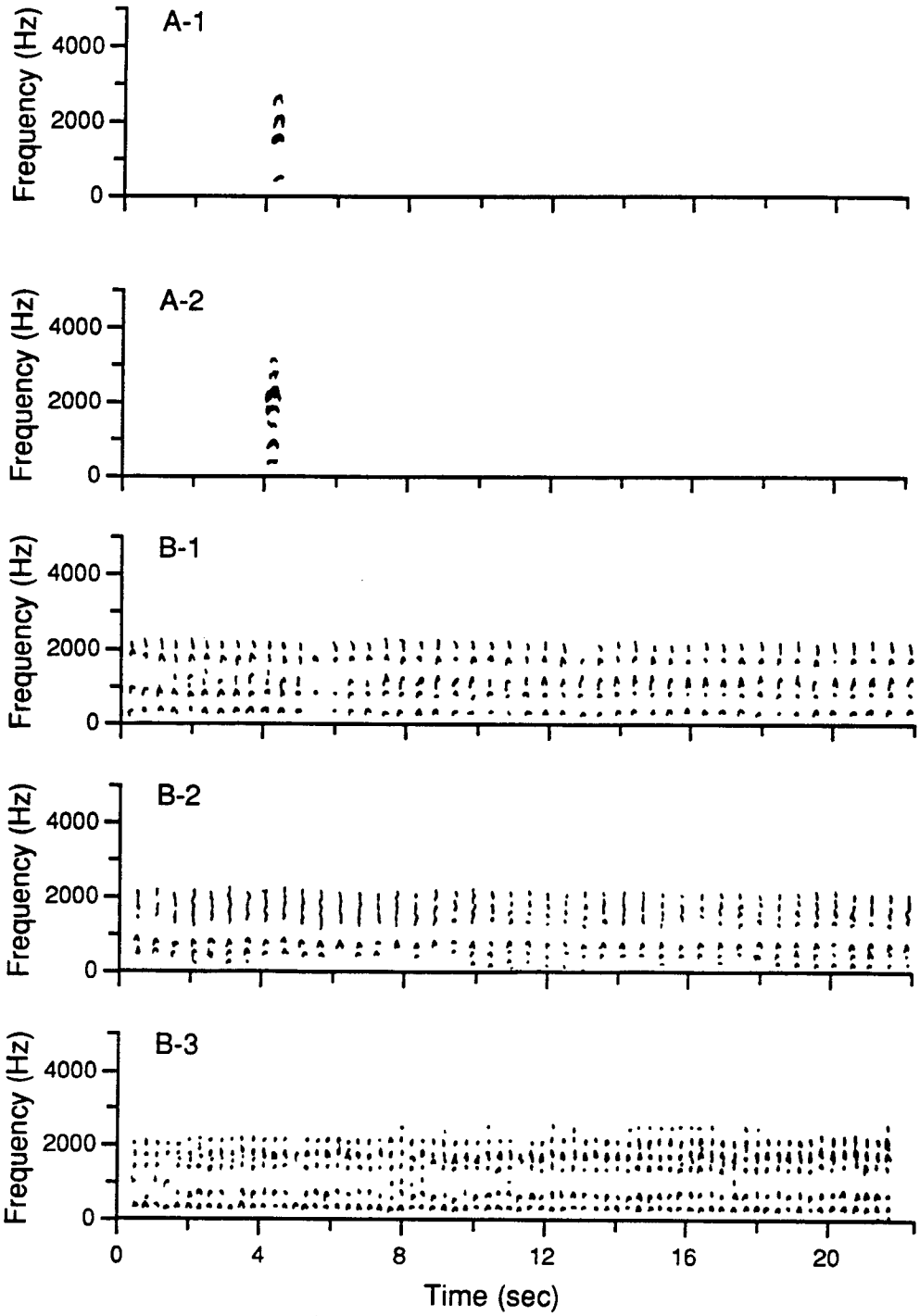

Fig. 10. Two types of calls emitted by males and/or females in 5 species of tragopans. Top to bottom-alarm call emitted only by males-A-1=Western, A-2=Temminck's, and alarm call uttered by both sexes-B-1=Satyr, B-2=Temminck's, B-3=Cabot's.

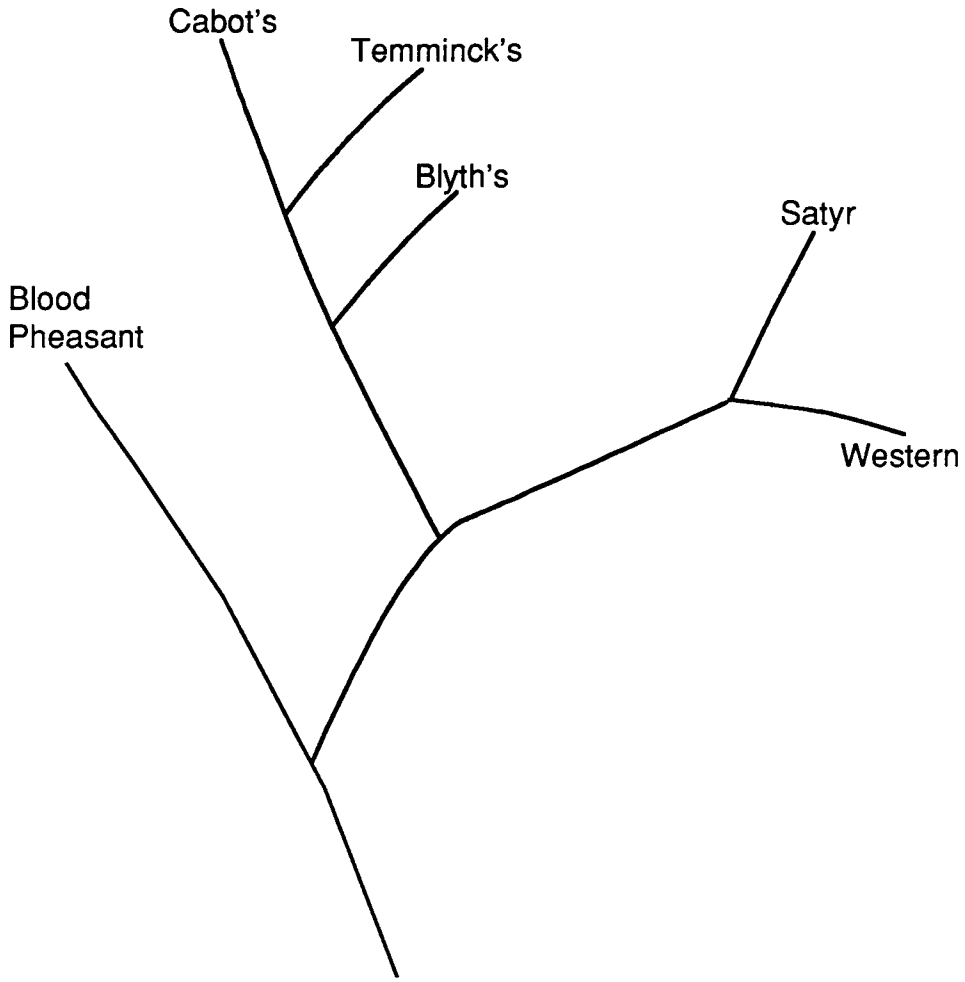

Fig. 11. Tree no. 1.

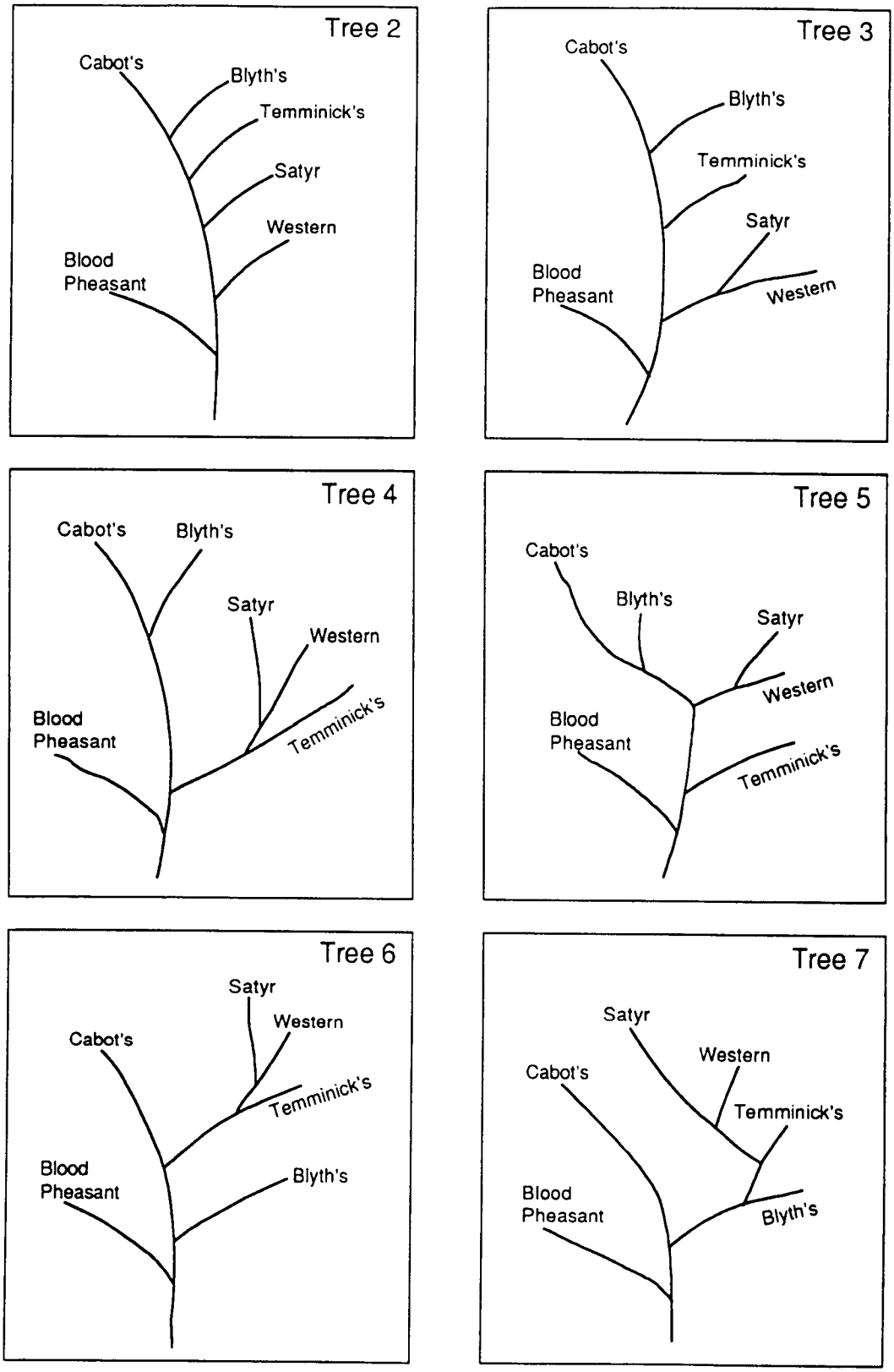

Fig. 12. Tree nos. 2 - 7.

Cabot's and Blyth's formed a cluster (Fig. 12, Trees 2-5) whereas, Satyr and Western were grouped together for six of the seven trees (Figs. 11 & 12, Trees 3-7). Temminck's was grouped in three instances each with the Cabot's-Blyth's pair (Figs. 11, 12, Trees 2 & 3) and the Satyr-Western pair (Fig. 12, Trees 4,6 & 7). In one instance each, Western (Fig. 12, Tree 2), Temminck's (Fig. 12, Tree 5), Blyth's (Fig. 12, Tree 6), and Cabot's (Fig. 12, Tree 7) were distant from the clusters.

DISCUSSION

Although unlike other pheasant species the genera Tragopan and Ithaginis molt their tail feathers centrifugally, there is no other evidence to suggest that these two groups are closely related. From a comparison of the morphological (quantitative external measurements and plumage description) and behavioral (qualitative assessment of the lateral display) data, it is evident that tragopans formed an isolated group and are not closely related to the Blood Pheasant. Tragopans did not share any plumage characteristics with Blood Pheasant for three age groups. Also, there was no overlap in external measurements between tragopans and Blood Pheasant for any age or sex category (Figs. 2 & 4). Blood Pheasants differed from tragopans in that males attained breeding plumage during the first year, whereas tragopans take two years for males to attain sexual maturity. Red facial skin was present in Blood Pheasant and Western Tragopan. However, red facial skin also occurs in numerous other genera of pheasants (e.g. Gallus, Crossoptilon, Lophura, Phasianus, Catreus) (Johnsgard 1986). The Blood Pheasant lacks a lappet and horns, whereas tragopans are unique among pheasants as they posess fleshy horns and colorful lappets. Several components of the lateral display (e.g. side-stepping towards the female, compression of the body) were not recorded in Blood Pheasant but were present in tragopans. Also, the Blood Pheasant was reported to make complete turns around the female (Beebe 1918-22), whereas tragopans only made half-turns towards the female. The only component of the lateral display that the Blood Pheasant and tragopans shared was the lowering of a wing towards the female. However, this component of the lateral display also occurs in other genera of pheasants (e.g. Phasianus, Lophophorus, Crossoptilon, Polyplectron) (Johnsgard 1986). No frontal displays have been described in the Blood Pheasant. The components of the frontal display in tragopans were highly stereotyped and complex and were unique to this genus. This information further suggests that tragopans have been isolated from other pheasants for a long period of time and the frontal display evolved in this group independently from other groups of pheasants. The flight, wing whir, and lappet displays

in tragopans were not reported in the Blood Pheasant. Unlike tragopans, no courtship/advertisement calls were described for the Blood Pheasant. A qualitative assessment of three different types of calls in the Blood Pheasant indicated that these calls were very different from the vocalizations produced by either sex of any species of tragopan (Figs. 5,7,9 &10).

External Morphology

Plumage-Because of extreme intra-specific variation in plumage coloration and pattern, it was not possible to identify chicks, immatures, and adult female/yearling tragopans with any certainty. The only exception was adult female/yearling Western Tragopan which was easily identified by its grayer coloration and prominent white ocelli outlined in black on the breast, belly, and back feathers (Appendix 5). Two explanations could account for the difference between Western Tragopans and the remaining species of tragopans. Johnsgard (1986) suggested that the grayer coloration of female Western Tragopans may be an ecological adaptation to the generally drier environment that it inhabits. A second explanation is that the Western Tragopan is phylogenetically distant from the other four species. In other genera of the subfamily Phasianinae it is possible to identify the female of a given species. However, tragopans are an exception as all species are very similar in appearance and are probably very closely related.

External Measurements-The close similarity among tragopan species also was apparent from a multivariate comparison of four external measurements in adult males (Fig. 2), yearling males (Fig. 3), and adult females/yearlings (Fig. 4). No information on the phylogenetic interrelationships in tragopans was inferred from these results. However, a comparison of the tail lengths of adult males and adult females/yearlings indicated that the 2 long-tailed species (Satyr & Western) were more closely related to each other than to the remaining three species of tragopans.

Coloration/Pattern of Facial Skin and Lappets-A comparison of the facial skin coloration among male tragopan species (Table 1) suggested that Blyth's and Cabot's were closely related to each other and that Temminck's and Satyr were related most closely to each other. However, a comparison of the size and ornateness of the lappets indicated that there was a distinct progression from small and simple to large and complex (Table 1). Blyth's Tragopan had the smallest and simplest lappet, which suggested that it retained some of the primitive characteristics of the ancestral population. Satyr and Western tragopans had moderately sized and patterned lappets and Temminck's and Cabot's had large and complex lappets which suggested that each pair of species had a common origin but was distinct from the other pair.

Behavior

Courtship Display

A comparison of the presence or absence of six components of the lateral display in males of four species of tragopans indicated that they all shared the same body postures and movements. The only difference was that Temminck's and Satyr tragopans arched their head towards the ground when they were in close proximity to a female. This movement was not observed in Blyth's and Cabot's, which always displayed in an upright stance. This information suggested that Temminck's and Satyr were more closely related to each other than either was to Blyth's and Cabot's tragopan.

Of the ten parts of the frontal display observed in males of four species of tragopans, there was a difference among species in only two components. The wing coordination of Blyth's Tragopan was characterized by slower and more labored wing beats compared to the other three species which suggests that Blyth's continues to retain some of the primitive characteristics of the ancestral population. Compared to Blyth's Tragopan, Satyr, Cabot's, and Temminck's appeared to have better coordinated wing flapping movements. Also, wing flapping in Cabot's occurred with the wings in a more outstretched position as compared to the other three species, and this

characteristic probably represents a derived condition. The remaining three courtship/territorial displays observed in males of all four closely observed species of tragopans suggests that these displays were probably present in the ancestral population of tragopans and have been retained in the modern day forms.

Vocalization

Results obtained from advertisement/courtship calls (Fig. 6) and clicking sounds produced during the frontal display in male tragopans (Fig. 8) were consistent with one another. Blyth's, Temminck's, and Satyr tragopans formed one acoustic group, whereas Cabot's and Western each formed separate groups. These results can be interpreted in one of two ways. One explanation is that Blyth's, Satyr, and Temminck's tragopans are closely related to each other and are only distantly related to Cabot's and Western tragopans. Another explanation is that Blyth's, Satyr, and Temminck's tragopans retained characteristics of the ancestral population but that these characteristics have been modified in the peripheral species (Western & Cabot's) (Fig. 1).

Biochemical Analysis

The presence of only four unique alleles in 36 proteins in four species of tragopans indicated that members of this genus were very closely related (Appendix 4). No unique allele was discovered in Blyth's Tragopan, which suggests that this species is probably the most primitive extant species. Satyr Tragopan differed from Cabot's and Temminck's in that it possessed two unique alleles as compared to one each in the latter two.

Numerical Cladistic Analysis

Based on a compilation of 25 characters, seven possible phylogenetic trees were generated. Satyr and Western tragopans were closely related in six cases (Figs. 11 & 12, Trees 3-7), whereas Blyth's and Cabot's were closely related in four instances (Fig. 12,

Trees 2-5). Temminck's Tragopan was the species most closely related to the Cabot's-Blyth's pair in two cases (Fig. 12, Trees 2 & 3) and was grouped with Blyth's & Cabot's in three instances (Figs. 11, 12, Trees 2 & 3). Also, Temminck's displayed a close relationship with the Satyr-Western pair in three cases (Fig. 12, Trees 4,6 & 7). No phylogenetic tree grouped either Cabot's or Blyth's tragopan with Satyr or Western tragopan.

In general, current evolutionary theory considers characters to evolve from a primitive (simple) to a derived (complex) state. Although a derived state may be lost over time, very seldom do characters revert back from a derived to a primitive condition.

Johnsgard (1986) proposed that tragopans represented two superspecies groups which consisted of Western, Satyr, and Temminck's as one group (most closely related) and Blyth's and Cabot's as a second group (most closely related species) (Fig. 13). However, these observations were based on the limited information available at that time and were drawn mainly from geographic distribution and on some morphological and ecological information. I accepted Tree 1 (Fig. 11) based on current geographical distribution, and morphological (size and lappet pattern complexity, grouping of tragopans according to tail length), behavioural (wing coordination during frontal display), and electrophoretic (number of unique alleles among the different species of tragopans) data. According to Tree 1, tragopans can be arranged phylogenetically into two groups; one group consists of Satyr and Western as closely related species and another group consists of Temminck's, Blyth's, and Cabot's tragopans with Temminck's and Cabot's being more closely related to each other than either is to Blyth's (Fig. 11).

I rejected Trees 2-7 (Fig. 12) based on current geographic distribution, size and complexity of the lappet, and wing coordination during the frontal display. Satyr, Temminck's, and Cabot's tragopans have well coordinated wing flapping during the frontal display whereas, it is poorly developed in Blyth's Tragopan. If one were to accept Trees 2, 3, 5, and 7 (Fig. 12), one would have to assume that poor wing coordination arose from a well coordinated wing movement which defies

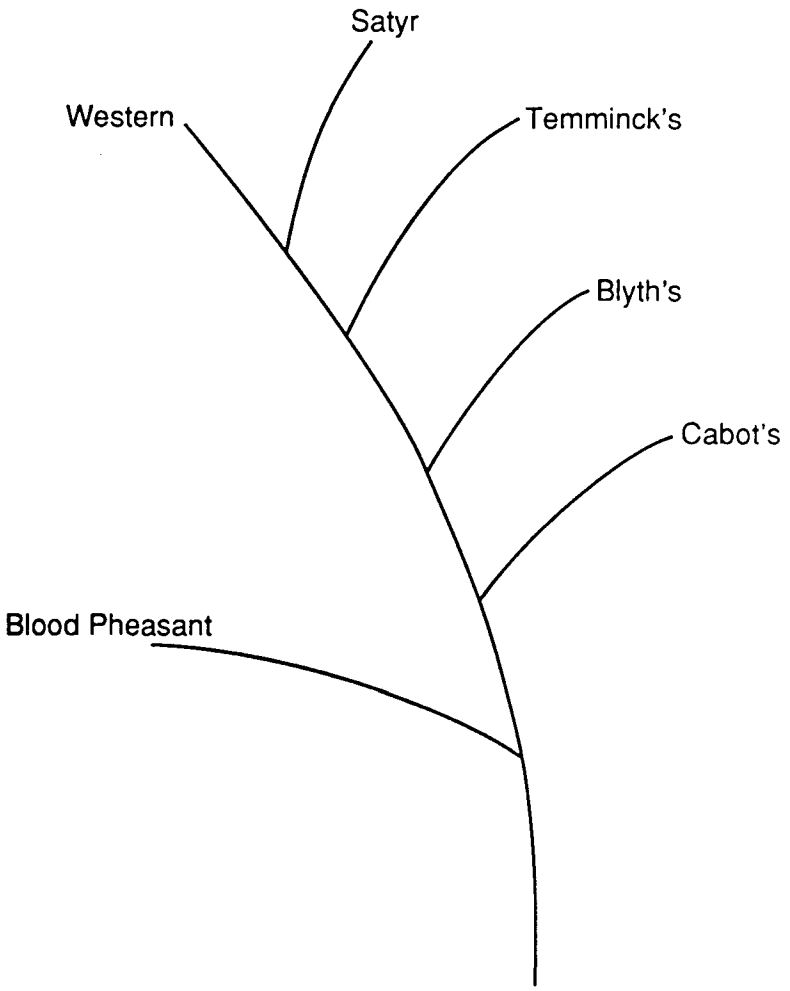

Fig. 13. A phylogenetic tree of the interrelationships among 5 species of tragopans and the Blood Pheasant as proposed by Johnsgard (1986).

current evolutionary thinking. Also, to accept Trees 2-5, and 6-7 (Fig. 12), one would have to assume that either a highly complex lappet (e.g in Cabot's and Temminck's) gave rise to a very simple one (e.g. in Blyth's) (Fig. 12, Trees 2 & 3) or that a complex lappet evolved independently in Temminck's and Cabot's tragopans (Fig. 12, Trees 4-7). The probability of such an occurrence in nature is very low. Based on their current distributions, Blyth's and Cabot's tragopans are allopatric (Fig. 1) and are separated from each other for a distance of more than 1500 km. It is difficult to conceive that Blyth's and Cabot's are very closely related in light of their current geographical distribution, especially since Temminck's Tragopan occupies the area between the two species (Fig. 1).

I propose the following scenario to illustrate how the extant species of tragopans might have evolved: **Step 1** -the prototype of tragopans probably had their origin in the eastern Himalayas. According to Johnsgard (1983b), one of the centers of pheasant diversity occurs in the vicinity of northern Burma and Yunnan and the upper reaches of the Yangtze, Mekong, Salween, and Irrawaddi rivers. The tragopan prototype population probably had horns, very short and simple lappets, ocelli and red coloration in plumage, colored facial skin, characteristic courtship/advertisement calls typical of extant species, lateral displays, and poorly coordinated frontal displays. **Step 2** -the original population split into two populations, A and B (Fig. 14) perhaps because of geological events in the eastern Himalayas. **Step 3** -the central and western Himalayas provided a corridor for dispersal of population B (Fig. 1). Johnsgard (1986) suggested that the Himalayas and their associated deserts served as a barrier to prevent the northward expansion of pheasants and was likely the case with tragopans. Population B retained general characteristics of population A. However, due to sexual selection in males, lappets increased in size and became moderately ornate. Frontal displays became much more stereotyped with well coordinated movements. Both sexes of population B increased in size. **Step 4** -due to geological events in the western Himalayas, population B further split into two populations, B and C (Fig. 14). Because of sexual selection, males of

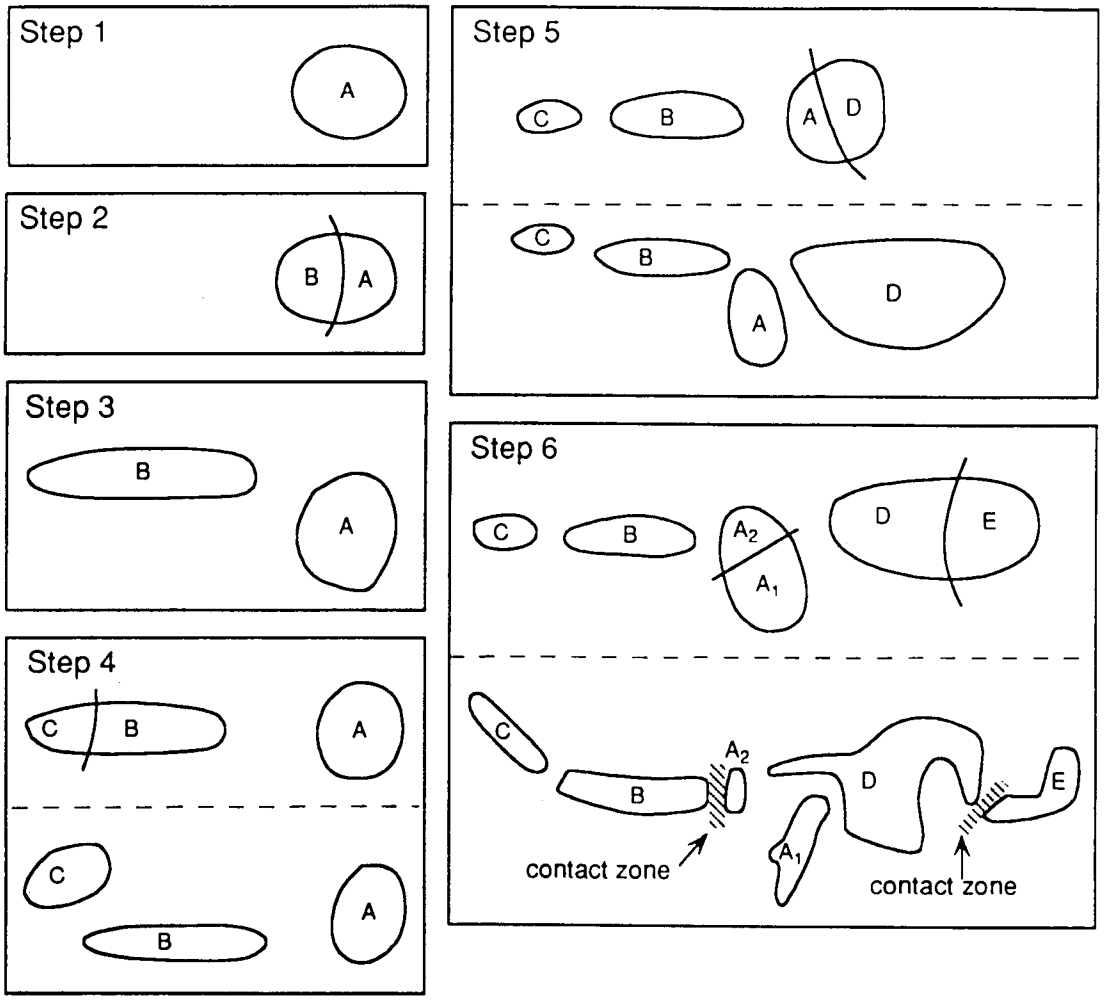

Fig. 14. A step-by-step scenario of the evolution of 5 species and 1 subspecies of tragopan. Step 1-Origin of tragopan prototype in eastern Himalayas. Step 2- Original population splits into 2, A & B. Step 3-Dispersal of population B. Step 4-Population B splits into 2, B & C which evolve into Satyr and Western, respectively. Step 5-Population A splits into 2 populations, A & D. Population D disperses. Step 6-Population A further splits into A_1 & A_2 which evolve into nominate Blyth's and subspecies Molesworthi. Population D separates into 2 populations, D & E, which evolve into Temminck's and Cabot's, respectively.

the two populations evolved different plumage coloration and facial skin. Courtship/territorial calls were modified in population C. However, both populations retained similarly colored and patterned lappets and long tails. Over time, populations B and C evolved into the extant species of Satyr and Western tragopans, respectively. The Satyr Tragopan is currently distributed throughout the central Himalayas, whereas Western Tragopans are restricted to the western Himalayas (Fig. 1) (Johnsgard 1986). Populations of the two species are allopatric but are separated from each other by only a few kilometers. **Step 5** -population A further splits into two populations, A and D, due to geological and/or glaciation events (Fig. 14). Population D continued to retain characteristics of population A, including smallness in size. However, due to sexual selection, males developed long and elaborately patterned lappets and well coordinated frontal displays with a greater complexity in the number of groups of clicks during this display. Population D dispersed extensively into southeast and southwest China. **Step 6** -because of an increase in the width of the Brahmaputra River, population A split into two populations, A1 and A2 (Fig. 14). Population D also separated into two populations, D and E, due to a geological or biological (restriction of gene flow in a subpopulation) barrier. Populations A1 and A2 retained similar characteristics except for some plumage differences in males. Due to sexual selection, males of the two populations, D and E, evolved different plumage characteristics and facial skin coloration. Courtship/advertisement calls in males of population E became greatly modified. Also, the components of the frontal display (wing flapping and number of groups of clicks) changed in population E. The size and complexity of pattern on the lappet, however, was retained in both groups. Over time, population A evolved into the Blyth's Tragopan. Currently, there are two recognized subspecies of Blyth's which consists of the nominate form (A1) which occurs in Burma and northeastern India and Molesworth's Blyth's (*T. b. molesworthi*) (A2) which occurs in southeast Tibet and Bhutan (Fig. 1). Currently, the distribution of Molesworth's Blyth's Tragopan overlaps with the eastern distribution of Satyr Tragopan. Due to allopatric and/or peripatric

speciation, populations D and E evolved into the extant forms Temminck's and Cabot's tragopans, respectively. Currently, Temminck's Tragopan ranges extensively into central China, whereas Cabot's Tragopan is restricted mainly to southeastern China (Johnsgard 1986). Both species have a narrow zone of contact in northeast Guangxi Zhuangu autonomous region in China (Fig. 1). Whereas Temminck's Tragopan inhabits high elevation (>1500 m) dense coniferous and mixed forests, Cabot's Tragopan occurs in mixed low elevation (<1500 m) forests with thick undergrowth. In addition to the ecological barrier that occurs between Cabot's and Temminck's tragopans, the following isolating mechanisms probably prevented the interbreeding of Cabot's and Temminck's and Blyth's and Satyr tragopans at zones of contact: male plumage coloration and pattern, coloration of facial skin, coloration and pattern of lappet, courtship/advertisement calls and clicking sounds produced during the frontal display, and variation in the lateral display.

As is evident from this research, a reliance on only one or two areas of investigation (e.g. morphology or behavior) could lead to very different results. Only if data from several areas of investigation are considered collectively, can an accurate portrayal of phylogenetic relationships be obtained.

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APPENDICES

Appendix 1. Sample size, mean ± 1 standard deviation, standard error, and range of 5 external variables from three age and sex categories of 5 species of tragopans and the Blood Pheasant.

Age/sex category Variable	Species	n	$\bar{x}$ ± 1.0 S.D.	Std. Err.	Range (mm)
Adult Male					
Tarsus Length	Cabot's	30	75.63 ± 3.48	0.64	68.8-85.7
	Satyr	41	82.65 ± 3.94	0.62	70.8-89.1
	Temminck's	76	76.93 ± 4.03	0.46	68.0-86.6
	Blyth's	21	83.89 ± 3.42	0.75	77.1-90.7
	Western	21	76.75 ± 2.29	0.50	72.4-81.4
	Blood	247	65.60 ± 2.76	0.18	54.9-73.5
Wing Chord	Cabot's	27	205.48 ± 6.90	1.33	191-216
	Satyr	35	231.06 ± 13.84	2.34	194-260
	Temminck's	77	215.84 ± 10.32	1.18	192-238
	Blyth's	6	215.00 ± 12.07	4.93	193-226
	Western	31	241.87 ± 6.23	1.12	228-253
	Blood	241	187.50 ± 10.41	0.67	149-214
Bill Width (at anterior end of nostrils)	Cabot's	30	9.52 ± 0.52	0.09	8.5-10.7
	Satyr	40	9.57 ± 0.54	0.09	8.5-10.8
	Temminck's	77	9.21 ± 0.54	0.06	8.1-10.5
	Blyth's	21	10.04 ± 0.60	0.13	8.9-11.0
	Western	31	9.78 ± 0.38	0.07	8.9-10.5
	Blood	251	9.63 ± 0.61	0.04	7.4-11.5
Bill Height (at anterior end of nostrils)	Cabot's	27	9.93 ± 1.04	0.20	7.3-12.4
	Satyr	30	9.34 ± 0.84	0.15	7.8-11.2
	Temminck's	60	10.00 ± 0.78	0.10	7.6-11.6
	Blyth's	16	10.88 ± 0.82	0.21	9.6-12.4
	Western	19	10.67 ± 0.92	0.21	8.0-12.2
	Blood	160	9.80 ± 0.81	0.06	7.9-11.9
Tail Length[1]	Cabot's	-	- -	-	210-215
	Satyr	-	- -	-	250-345
	Temminck's	-	- -	-	185-230
	Blyth's	-	- -	-	180-220
	Western	-	- -	-	220-250
	Blood	-	- -	-	164-178

Appendix 1 Continued.

Age/sex category Variable	Species	n	$\bar{x} \pm 1.0$ S.D.	Std. Err.	Range (mm)
Yearling Male					
Tarsus Length	Cabot's	7	75.46 ± 1.37	0.52	73.5-77.0
	Satyr	8	81.61 ± 4.98	1.76	72.7-87.9
	Temminck's	27	76.79 ± 2.94	0.57	71.7-85.1
	Blyth's	5	80.74 ± 4.89	2.19	72.2-84.6
	Western	10	76.96 ± 4.36	1.38	69.9-81.9
Wing Chord	Cabot's	6	192.67 ± 4.63	1.89	187-198
	Satyr	8	213.38 ± 8.23	2.91	202-226
	Temminck's	27	198.22 ± 9.54	1.84	183-222
	Blyth's	6	215.00 ± 12.07	4.93	193-226
	Western	16	224.88 ± 5.66	1.41	211-231
Bill Width (at anterior end of nostrils)	Cabot's	7	8.76 ± 0.85	0.32	7.2-9.9
	Satyr	8	9.26 ± 0.47	0.16	8.4-10.0
	Temminck's	27	8.91 ± 0.65	0.12	7.5-10.2
	Blyth's	6	9.57 ± 0.72	0.29	8.8-10.9
	Western	16	9.46 ± 0.43	0.11	8.7-10.2
Bill Height (at anterior end of nostrils)	Cabot's	5	9.38 ± 0.73	0.33	8.3-10.1
	Satyr	8	9.11 ± 0.73	0.26	8.0-10.2
	Temminck's	21	9.41 ± 0.70	0.15	8.3-10.9
	Blyth's	3	9.47 ± 0.12	0.07	9.4-9.6
	Western	7	10.34 ± 0.48	0.18	9.8-11.1

Appendix 1 Continued.

Age/sex category Variable	Species	n	$\bar{x} \pm 1.0$ S.D.	Std. Err.	Range (mm)
Adult Female/Yearling					
Tarsus Length	Cabot's	18	66.72 ± 4.71	1.11	60.0-81.8
	Satyr	25	69.74 ± 3.02	0.60	61.3-73.3
	Temminck's	65	65.54 ± 3.44	0.43	58.9-73.0
	Blyth's	20	71.79 ± 4.85	1.09	62.6-84.6
	Western	5	65.70 ± 2.48	1.11	62.6-68.7
	Blood	140	61.01 ± 2.26	0.19	55.1-65.8
Wing Chord	Cabot's	16	185.44 ± 11.11	2.78	163-213
	Satyr	21	204.95 ± 11.01	2.40	181-226
	Temminck's	62	192.27 ± 10.17	1.29	170-213
	Blyth's	20	205.70 ± 7.60	1.70	190-216
	Western	5	210.0 ± 4.95	2.21	204-217
	Blood	132	173.75 ± 9.02	0.78	153-193
Bill Width (at anterior end of nostrils)	Cabot's	17	8.46 ± 0.61	0.15	7.5-9.7
	Satyr	24	8.63 ± 0.38	0.08	7.9-9.3
	Temminck's	67	8.31 ± 0.55	0.07	7.4-9.9
	Blyth's	20	9.24 ± 0.63	0.14	8.3-10.4
	Western	5	8.76 ± 0.27	0.12	8.5-9.1
	Blood	138	9.15 ± 0.56	0.05	7.2-10.2
Bill Height (at anterior end of nostrils)	Cabot's	16	8.59 ± 0.85	0.21	7.1-10.4
	Satyr	22	8.64 ± 0.61	0.13	7.3-9.5
	Temminck's	53	8.52 ± 0.67	0.09	6.6-9.7
	Blyth's	17	9.66 ± 0.97	0.24	8.3-11.5
	Western	4	9.23 ± 0.26	0.13	9.0-9.6
	Blood	94	9.22 ± 0.93	0.10	6.8-11.2
Tail Length[1]	Cabot's	-	-	-	160-168
	Satyr	-	-	-	195
	Temminck's	-	-	-	175
	Blyth's	-	-	-	170-175
	Western	-	-	-	190-200
	Blood	-	-	-	140-154

[1] From Delacour 1977.

Appendix 2. Sample size, mean ± 1 standard deviation, standard error, and range of 6 vocal parameters in males of 5 species of tragopans measured from spectrographs.

Variable	Species	n	$\bar{x}$ ± 1.0 S.D.	Std. Err.	Range
Number of notes per sequence	Cabot's	19	9.05 ± 5.94	1.36	5.0-25.0
	Satyr	50	8.46 ± 2.56	0.36	3.0-17.0
	Temminck's	30	7.43 ± 1.94	0.35	4.0-12.0
	Blyth's	39	7.41 ± 1.90	0.30	3.0-11.0
	Western	42	11.17 ± 5.93	0.92	3.0-36.0
Note duration (sec)	Cabot's	19	0.20 ± 0	0	0.2
	Satyr	50	0.86 ± 0.18	0.03	0.6-1.3
	Temminck's	30	0.71 ± 0.10	0.02	0.6-0.9
	Blyth's	39	1.35 ± 0.15	0.02	1.1-1.8
	Western	42	0.60 ± 0.07	0.01	0.4-0.7
Note interval (sec)	Cabot's	19	0.33 ± 0.18	0.04	0.1-0.9
	Satyr	50	2.12 ± 0.74	0.10	1.2-4.2
	Temminck's	30	1.31 ± 0.34	0.06	0.9-2.4
	Blyth's	39	3.01 ± 0.55	0.09	2.3-4.9
	Western	42	3.45 ± 1.29	0.20	1.8-5.8
Lowest frequency (H_3)	Cabot's	19	150 ± 0	0	150
	Satyr	50	200 ± 0	0	200
	Temminck's	30	200 ± 0	0	200
	Blyth's	39	200 ± 0	0	200
	Western	42	400 ± 0	0	400
Highest frequency (H_3)	Cabot's	19	4400 ± 0	0	4400
	Satyr	50	2148 ±322.77	45.65	1600-2400
	Temminck's	30	2446.67 ±322.42	58.87	1600-3000
	Blyth's	39	2112.82 ±164.12	26.28	1800-2200
	Western	42	2600 ± 0	0	2600
Total time of call (sec)	Cabot's	19	3.80 ± 1.70	0.39	2.2-8.0
	Satyr	50	23.66 ± 9.55	1.35	8.2-55.4
	Temminck's	30	14.49 ± 5.35	0.98	5.8-26.6
	Blyth's	39	29.69 ± 7.88	1.26	9.4-45.0
	Western	42	45.12 ± 37.58	5.80	8.4-197.0

Appendix 3. Sample size, mean ± 1 standard deviation, standard error, and range of 5 parameters for the clicking segment of the frontal display in males of 4 species of tragopans measured from spectrographs.

Variable	Species	n	$\bar{x}$ ± 1.0 S.D.	Std. Err.	Range
Total number of clicks/ display	Cabot's	29	15.17 ± 3.83	0.71	9.0-20.0
	Satyr	27	15.30 ± 3.42	0.66	10.6-24.0
	Temminck's	27	22.96 ± 5.88	1.13	10.0-34.0
	Blyth's	3	9.0 ± 1.0	0.58	8.0-10.0
Highest number of group(s) of clicks	Cabot's	29	4.93 ± 0.26	0.05	4.0-5.0
	Satyr	27	1.56 ± 0.51	0.10	1.0-2.0
	Temminck's	27	1.96 ± 0.19	0.04	1.0-2.0
	Blyth's	3	1.0 ± 0	0	1.0
Lowest number of group(s) of clicks	Cabot's	29	2.0 ± 0	0	2.0
	Satyr	27	1.0 ± 0	0	1.0
	Temminck's	27	1.0 ± 0	0	1.0
	Blyth's	3	1.0 ± 0	0	1.0
Highest frequency (H_3)	Cabot's	29	8558.62±1362.12	252.94	6200-10,000
	Satyr	27	8696.30±1416.79	272.66	6200-10,000
	Temminck's	27	8770.37±1538.93	296.17	6000-10,000
	Blyth's	3	9400 ±1039.23	600.00	8200-10,000
Total time of segment (sec)	Cabot's	29	11.55 ± 5.68	1.05	4.2-20.3
	Satyr	27	11.08 ± 4.08	0.78	4.3-20.2
	Temminck's	27	22.10 ± 12.12	2.33	7.5-65.0
	Blyth's	3	4.87 ± 1.01	0.58	3.8-5.8

Appendix 4. Allelic frequencies of polymorphic and monomorphic loci in 4 species of tragopans.

Enzyme Name (E.C. Number)	Locus	Allele	Frequency C[1] n=7	S n=5	T n=4	B n=4
I. Polymorphic Loci						
Isocitrate Dehydrogenase (1.1.1.42)	IDH-1	A	1.00	1.00	0.00	1.00
		B	0.00	0.00	1.00	0.00
Aconitase Hydratase (4.2.1.3)	ACOH-1	A	1.00	0.00	0.00	0.00
		B	0.00	1.00	1.00	1.00
Fumarate Hydratase (4.2.1.2)	FUMH-1	A	1.00	0.00	1.00	1.00
		B	0.00	1.00	0.00	0.00
Peptidase (3.4.-.-)	PEP-LT-2	A	1.00	0.00	1.00	1.00
		B	0.00	1.00	0.00	0.00

II. Monomorphic Loci

Enzyme Name (E.C. Number)	Locus
L-Lactate Dehydrogenase (1.1.1.27)	LDH-1 LDH-2
Malate Dehydrogenase (1.1.1.37)	MDH-1 MDH-2
Malate Dehydrogenase (NADP+) (1.1.1.40)	MDHP-1 MDHP-2
Xanthine Dehydrogenase (1.1.1.204)	XDH
Creatine Kinase (2.7.3.2)	CK
Alcohol Dehydrogenase (1.1.1.1)	ADH
Mannose-6-phosphate Isomerase (5.3.1.8)	MPI
Superoxide Dismutase (1.15.1.1)	SOD-1 SOD-2

Appendix 4 Continued.

Enzyme Name (E.C. Number)	Locus
L-Iditol Dehydrogenase (1.1.1.14)	IDDH-1 IDDH-2 IDDH-3
Glycerol-3-phosphate Dehydrogenase (1.1.1.8)	G3PDH-1 G3PDH-2 G3PDH-3
Glutamate Dehydrogenase (1.4.1.2)	GTDH
Isocitrate Dehydrogenase (1.1.1.42)	IDH-2
Aconitase Hydratase (4.2.1.3)	ACOH-2
Glucose-6-phosphate Dehydrogenase (1.1.1.49)	G6PDH
Phosphoglucomutase (5.4.2.2)	PGM-1 PGM-2 PGM-3 PGM-4
Phosphogluconate Dehydrogenase (1.1.1.44)	PGDH-1 PGDH-2
Adenylate Kinase (2.7.4.3)	AK
ß-N-Acetylglactosaminidase (3.2.1.53)	ßGALA
Esterase-D (3.1.1._)	Est-D
Esterase (nonspecific) (3.1.1.1)	Est
Diaphorase	DIA-1 DIA-2 DIA-3
Octanol Dehydrogenase (1.1.1.73)	ODH
Acid Phosphatase (3.1.3.2)	ACP
Purine-nucleoside Phosphorylase (2.4.2.1)	PNP-1 PNP-2
Hexokinase (2.7.1.1)	HK
Glyceraldehyde-3-phosphate Dehydrogenase (1.2.1.12)	GAPDH-1 GAPDH-2

Appendix 4 Continued.

Enzyme Name (E.C. Number)	Locus
Fumarate Hydratase (4.2.1.2)	FUMH-2
Glutathione Reductase (1.6.4.2)	GR
Glucose-6-phosphate Isomerase (5.3.1.9)	GPI-1 GPI-2
Fructose-biphosphate Aldolase (4.1.2.1.13)	FBA-1 FBA-2
Peptidase-Glycyl-L-Leucine	PEP-GL-1 PEP-GL-2
Peptidase-L-Phenylalanyl-L-Proline	PEP-PHAP
Peptidase-L-Leucylglycylglycine	PEP-LGG-1 PEP-LGG-2
Peptidase	PEP-LT-1 PEP-LT-3
Peptidase-DL-Leucylglycine	PEP-LG-1 PEP-LG-2
Peptidase-L-Phenylalanylgylcylglycyl-L-Phenylalanine	PEP-PGGP

[1] C = Cabot's, S = Satyr, T = Temminck's, B = Blyth's

Appendix 5. Variation in plumage coloration and pattern among 5 species of tragopans and Blood Pheasant for 3 age categories.

Age Category/ Body Region	Species (n)	Background coloration	Pattern
CHICK			
Crown & Forehead	Cabot's (7)	Cinnamon (39) & raw sienna (136) tinged with black	
	Satyr (6)	Amber (36) bordered by jet black (89) towards nape	
	Temminck's (5)	Chamois (123D) tinged with raw sienna (136)	
	Blyth's (4)	Amber (36) bordered by dull black	
	Western (1)	Raw sienna (136) streaked with black	
	Blood (14)	Black with white on either side-raw sienna (136) tipped with black-cinnamon (123A) vermiculations tinged with antique brown (37) & pale horn (92)-cinnamon (123A) barring	
Back	Cabots (7)	Black	
	Satyr (6)	Raw sienna (136) with dull black	
	Temminck's (5)	Chamois (123D) tinged with raw sienna (136)	
	Blyth's (4)	Vandyke brown (121) tipped with raw sienna (136)	
	Western (1)	Raw sienna (136) streaked with black	
	Blood (14)	Raw sienna (136) with patches of black-antique brown (37) with black vermiculations-black-cinnamon (123A) vermiculations-buff (124) tinged with warm buff (118) & chamois (123D)	
Upper Wing Coverts	Cabots (7)	Black	Cinnamon (39) & sayal brown (223C) vermiculations
	Satyr (6)	Vandyke brown (121)	Warm buff (118) & chamois (123D) vermiculations-chamois (123D) ocellus with sayal brown (223C) vermiculations
	Temminck's (5)	Vandyke brown (121)-black	Buff (124) ocellus with cinnamon (39) & raw sienna (136) vermiculations-pale horn (92) ocellus

Appendix 5 Continued.

Age Category/ Body Region	Species (n)	Background coloration	Pattern
CHICK Upper Wing Coverts	Blyth's (4)	Vandyke brown (121)	Buff (124) & warm buff (118) tipped with cinnamon (39) & tawny olive (223D) vermiculations on sides
	Western (1)	Prout's brown (121A)	Pale horn (92) shaft tipped with tawny olive (223D)
	Blood (14)	Antique brown (37)-black-vandyke brown (121)	Black vermiculations and buff (124) ocellus-cinnamon (123A) vermiculations tipped with pale horn (92) ocellus-cream (54) ocellus-chamois (123D) vermiculations-buff (124) vermiculations
Throat	Cabots (7)	Cream (54)	
	Satyr (6)	Cream (54) tinged with buff yellow (53)-tipped with black	
	Temminck's (5)	Cream (54)-pale horn (92)	
	Blyth's (4)	Pale horn (92)-cream (54) tipped with black	
	Western (1)	Pale horn (92)	
	Blood (14)	Dull white-tipped with black-pale horn (92) tinged with chamois (123D)	
Breast & Belly	Cabots (7)	Cream (54)	
	Satyr (6)	Warm buff (118) tipped with dull black-cream (54)	
	Temminck's (5)	Pale horn (92)	
	Blyth's (4)	Pale horn (92) tipped with warm buff (118)-cream (54)	
	Western (1)	Ground cinnamon (239) tipped with pale horn (92)	
	Blood (14)	Pale horn (92) tipped with yellow ocher (123C)-buff (124)-cinnamon (123A) & clay (26) with black vermiculations-cream (54)-chamois (123D)-white	

Appendix 5 Continued.

Age Category/ Body Region	Species (n)	Background coloration	Pattern
IMMATURE			
Crown	Cabots (3)	Prout's brown (121A)-black	Mikado brown (121C) vermiculations with buff (124) shaft streak-chamois (123D) & buff yellow (53) ocellus tipped with amber(36)-pale horn (92) tipped with raw sienna (136)
	Satyr (6)	Vandyke brown (221)-black	Ocellus pale horn (92)-tawny (38) tip-chamois (123D) ocellus-buff (124) central streak with black on sides
	Temminck's (6)	Black	Pale horn (92) ocellus-white ocellus tipped with antique brown (37)
	Blyth's (3)	Black	Chamois (123D) ocellus with cinnamon (39) tip
	Blood (7)	Clay (26)-Vandyke brown (121)-medium neutral gray (84)-cinnamon (39) tinged with Pratt's rufous (140)-black	Cinnamon (39) spots & medium neutral gray (84) crest-yellow ocher (123C) bars-white streaks bordered with black
Back	Cabots (3)	Jet black (89)-dull black	Raw sienna (136) & buff (124) vermiculations with minute pale horn (92) ocellus & shaft streak-buff yellow (53), cream (54), yellow ocher (123C) & chamois (123D) vermiculations-white ocellus & tawny (38), cinnamon (39) & amber (36) vermiculations
	Satyr (6)	Vandyke brown (221)-black	Warm buff (118) vermiculations & cream (54) & warm buff (118) ocellus-cinnamon (123A) vermiculations-chamois (123D) ocellus & buff (124) vermiculations-pale horn (92) ocellus with clay (123B) & chamois (123D) vermiculations-Brussel's brown (121B), mikado brown (121C) & yellow ocher (123C) vermiculations

Appendix 5 Continued.

Age Category/ Body Region	Species (n)	Background coloration	Pattern
IMMATURE Back	Temminck's (6)	Black	Fine cinnamon (123A) & clay (123B) vermiculations-narrow white lanceolate ocellus & yellow ocher (123C) & chamois (123D) vermiculations
	Blyth's (3)	Black	Chamois (123D) ocellus & antique brown (37), cinnamon (123A), tawny olive (223D) & warm buff (118) vermiculations
	Blood (7)	Vandyke brown (121)-medium neutral gray (84)-black	Very fine pale pinkish buff (121D) vermiculations tinged with medium neutral gray (84)-yellow ocher (123C) vermiculations-white shaft bordered with black-cinnamon (39), sayal brown (223C) & tawny olive (223D) vermiculations-cinnamon (123A) vermiculations, white shaft streak tipped with pale horn (92) triangle
Rump	Cabots (3)	Vandyke brown (121)-dull black-black	Very fine antique brown (37) vermiculations-buff yellow (53), cream (54), yellow ocher (123C), chamois (123D) & pale horn (92) vermiculations-white ocellus & tawny (38), cinnamon (39) & amber (36) vermiculations
	Satyr (6)	Vandyke brown (121)-black	Finely vermiculated with cream (54)-cream (54) ocellus with cinnamon (123A) vermiculations-chamois (123D) ocellus with buff (124) vermiculations-pale horn (92) ocellus with clay (123B) & chamois (123D) vermiculations-Brussel's brown (121B), mikado brown (121C) & yellow ocher (123C) vermiculations
	Temminck's (6)	Black	Very fine cinnamon (123A) & clay (123B) vermiculations-yellow ocher (123C) & chamois (123D) vermiculations

Appendix 5 Continued.

Age Category/ Body Region	Species (n)	Background coloration	Pattern
IMMATURE Rump	Blyth's (3)	Black	Chamois (123D) ocellus with antique brown (37), cinnamon (123A), tawny olive (223D) & warm buff (118) vermiculations
	Blood (7)	Vandyke brown (121)-medium neutral gray (84)-black	Very fine pale pinkish buff (121D) vermiculations tinged with medium neutral gray (84)-yellow ocher (123C) vermiculations-white shaft bordered with black-cinnamon (39), sayal brown (223C) & tawny olive (223D) vermiculations-cinnamon (123A) vermiculations, white shaft streak tipped with pale horn (92) triangle
Upper Wing Coverts	Cabots (3)	Jet black (89)-Vandyke brown (121)-black	Cinnamon (39) vermiculations with buff (124) shaft-buff (24) & trogon yellow (153) vermiculations with narrow trogon yellow (153) shaft-buff (124) ocellus with tawny (38) & cinnamon (39) bars & vermiculations
	Satyr (6)	Dull black-black	Lanceolate cream (54) ocellus with black on sides & buff (124) vermiculations-white ocellus with cinnamon (39) & tawny olive (223D) bars & vermiculations-chamois (123D) ocellus with warm buff (118), antique brown (37), tawny (38) & cinnamon (123A) vermiculations-cinnamon (39) & chamois (123D) ocellus-pale horn (92) ocellus with clay (123B), yellow ocher (123C) & chamois (123D) vermiculations
	Temminck's (6)	Black	Cinnamon (39) vermiculations-pale horn (92) ocellus
	Blyth's (3)	Black	Cream (54) ocellus with cinnamon (39) & tawny (38) vermiculations

Appendix 5 Continued.

Age Category/ Body Region	Species (n)	Background coloration	Pattern
IMMATURE Upper Wing Coverts	Blood (7)	Vandyke brown (121)-black	Very fine pale pinkish buff (121D) vermiculations tinged with medium neutral gray (84)-yellow ocher (123C) vermiculations tipped with pale horn (92) ocellus-cinnamon (39), ground cinnamon (239) & saya1 brown (223C) vermiculations-tawny olive (223D) vermiculations-cinnamon (123A) vermiculations with white shaft tipped with pale horn (92) triangle
Rectrices	Cabots (3)	Vandyke brown (121)-black	Buff (124) & raw sienna (136) bars-amber (36), jet black (89), clay (26), raw sienna (136) & antique brown (37) vermiculations-mottled with antique brown (37), cinnamon (39), mikado brown (121C), true cinnamon (139), saya1 brown (223C) & tawny olive (223D)
	Satyr (6)	Black	Antique brown (37), cinnamon (39) & buff yellow (53) vermiculations with incomplete dull black bars-alternating black, pale pinkish buff (121D), verona brown (223A), Prout's brown (121A), Brussel's brown (121B), mikado brown (121C) & tawny olive (223D) bands-alternating antique brown (37), cinnamon (39) & saya1 brown (223C) bands
	Temminck's (6)	Black	Vermiculated bands of cinnamon brown (33), cinnamon (39), raw umber (23), mikado brown (121C) & cinnamon (123A)-finely vermiculated bands of saya1 brown (223C)
	Blyth's (3)	Black	Alternating bands of black, tawny olive (223D), saya1 brown (223C), Prout's brown (121A), Brussel's brown (121B), mikado brown (121C) & raw umber (23) with white ocellus towards tip

Appendix 5 Continued.

Age Category/ Body Region	Species (n)	Background coloration	Pattern
IMMATURE Rectrices	Blood (7)	Vandyke brown (121)	Very fine pale pinkish buff (121D) vermiculations with a tinge of medium neutral gray (84)-light drab (119C), pale horn (92) & white vermiculations forming indistinct bars-sayal brown (223C), tawny olive (223D) & cinnamon (39) barring & vermiculations-feathers edged with pink (7)-white central shaft with mikado brown (121C) barring
Throat	Cabots (3)	Buff (124) edged with warm buff (118) & dark brownish olive (129)-dull white with yellow ocher (123C) on the edges-black edges	
	Satyr (6)	Dull white tipped with warm buff (118) & edged with dull black-buff (124)	
	Temminck's (6)	White tinged with yellow ocher (123C) & buff (124) & edged in black	
	Blyth's (3)	Dull white with dull black edges	
	Blood (7)	Cinnamon (39)-light neutral gray (85) tipped with chamois (123D)-medium neutral gray (84) with white shaft streak-clay (26)-white tinged with warm buff (118)-dark neutral gray (83)	
Breast	Cabots (3)	Vandyke brown (121)-dull black-black	Cinnamon (39) vermiculations with pale horn (92) ocellus-yellow ocher (123C) & trogon yellow (153) vermiculations with white ocellus bordered with black-tawny (38), warm buff (118) & chamois (123D) vermiculations

Appendix 5 Continued.

Age Category/ Body Region	Species (n)	Background coloration	Pattern
IMMATURE Breast	Satyr (6)	Yellow ocher (123C)-dull black-black	Dark neutral gray (83) vermiculations with cream (54) ocellus-white ocellus finely vermiculated with buff (124), cinnamon (123A) & raw sienna (136)-pale horn (92) ocellus-cinnamon (39), pale pinkish buff (121D) & warm buff (118) vermiculations-clay (123B), yellow ocher (123C) & pale horn (92) vermiculations-ocellus edged with black
	Temminck's (6)	Black	White ocellus with cinnamon (123A), clay (123B), yellow ocher (123C) & chamois (123D) vermiculations-cinnamon (39) vermiculations
	Blyth's (3)	Dull black	White ocellus finely vermiculated with cinnamon (123A), clay (123B), yellow ocher (123C) & tawny olive (223D)
	Blood (7)	Clay (26)-Vandyke brown (121)	Very fine dull black vermiculations-clay (123B) vermiculations & tipped with pale horn (92) ocellus-pale horn (92) shaft & cinnamon (123A), yellow ocher (123C) & chamois (123D) vermiculations-white shaft
IMMATURE Belly	Cabots (3)	Buff (124)-dull black-black	Yellow ocher (123C) & trogon yellow (153) vermiculations with white ocellus bordered with dull black-tawny (38), cinnamon (39), warm buff (118) & chamois (123D) vermiculations
	Satyr (6)	Light neutral gray (85) tipped with pale neutral gray (86)-dull black-black	White ocellus with sayal brown (223C), tawny olive (223D) & cinnamon (39) vermiculations-pale pinkish buff (121D) vermiculations-warm buff (118) vermiculations-clay (123B), yellow ocher (123C) & pale horn (92) vermiculations-pale horn (92) ocellus outlined in black with cinnamon (123A) & clay (26) vermiculations

Appendix 5 Continued.

Age Category/ Body Region	Species (n)	Background coloration	Pattern
IMMATURE Belly	Temminck's (6)	Black	White ocellus with cinnamon (123A), clay (123B), yellow ocher (123C) & chamois (123D) vermiculations-cinnamon (39) vermiculations
	Blyth's (3)	Dull black	White ocellus finely vermiculated with cinnamon (123A), clay (123B), yellow ocher (123C) & tawny olive (223D)
	Blood (7)	Clay (26)-Vandyke brown (121)	Clay (123B) vermiculations tipped with pale horn (92) ocellus-pale horn (92) shaft and cinnamon (123A), yellow ocher (123C) & chamois (123D) vermiculations-white barring
Crissum	Cabots (3)	Black	Finely vermiculated with verona brown (223B), jet black (89) & antique brown (37)-amber (36), clay (26) & raw sienna (136) vermiculations-white ocellus with mikado brown (121C), sayal brown (223C) & tawny olive (223D) vermiculations
	Satyr (6)	Medium neutral gray (84)-black	Chamois (123D) vermiculations with cream (54) ocellus-white ocellus with sayal brown (223C) vermiculations-mikado brown (121C) & tawny olive (223D) vermiculations-cinnamon (39) vermiculations-pale horn (92) & tawny olive (223D) bands
	Temminck's (6)	Black	Buff (124) ocellus with cinnamon (123A) vermiculations-white ocellus with sayal brown (223C) & tawny olive (223D) vermiculations
	Blyth's (3)	Dull black	White ocellus with cinnamon (39) vermiculations

Appendix 5 Continued.

Age Category/ Body Region	Species (n)	Background coloration	Pattern
IMMATURE Crissum	Blood (7)	Vandyke brown (121)	Very fine pale pinkish buff (121D) vermiculations tinged with medium neutral gray (84)-yellow ocher (123C) vermiculations-pale horn (92) barring-cinnamon (39), sayal brown (223C) & tawny olive (223D) vermiculations-cinnamon (123A) vermiculations with white shaft & tipped with pale horn (92) triangle
YEARLING/ ADULT FEMALE			
Crown	Cabots (12)	Jet black (89)-black	Pale horn (92) shaft tipped with raw sienna (136)-Pratt's rufous (140) vermiculations at tip-cream (54) shaft tipped with tawny (38)-cream(54) ocellus-pale horn (92) ocellus tipped with amber (36)-tipped with cinnamon (123A)-white ocellus tipped with cinnamon (39)
	Satyr (20)	Dull black-black	Dull white & buff yellow (53) vermiculations-cream (54) center tipped with clay (123B)-pale horn (92) ocellus tipped with warm buff (118)-clay (123B) & raw sienna (136) ocellus-chamois (123D) ocellus tipped with raw sienna (136)-tipped with clay (26)-tipped with cinnamon (123A)-warm buff (118) ocellus-tipped with antique brown (37) & tawny (38)-tipped with amber (36)-buff (124)

Appendix 5 Continued.

Age Category/ Body Region	Species (n)	Background coloration	Pattern
YEARLING/ ADULT FEMALE Crown	Temminck's (59)	Jet black (89)-dull black-black	Edged with raw sienna (136) with a buff (124) ocellus-dull white ocellus with yellow ocher (123C) edges & sides-cream (54) ocellus-cinnamon (123A) tip-chamois (123D) ocellus tipped with raw sienna (136)-clay (123B) tip-buff yellow (53) & warm buff (118) ocellus-white shaft-pale horn (92) ocellus tipped with mikado brown (121C)-tipped with cinnamon (39)-clay (123B) shaft-tipped with yellow ocher (123C)-tipped with antique brown (37)
	Blyth's (20)	Blackish neutral gray (82)-dull black-black	Amber (36) vermiculations-cream (54) center-chamois (123D) ocellus tipped with amber (36)-tipped with raw sienna (136)-tipped with clay (123B)-tipped with cinnamon (123A)-buff (124) ocellus tipped with antique brown (37)-pale horn (92) ocellus-tipped with yellow ocher (123C)-white ocellus-buff (124) shaft-tipped with mikado brown (121C)
	Western (5)	Black	White shaft-pale horn (92) ocellus with cinnamon (123A) vermiculations-white ocellus
	Blood (132)	Medium neutral gray (84) crest-cinnamon (123A)-antique brown (37)-raw sienna (136) & tawny (38)-dark neutral gray (83) crest-cinnamon brown (33) & light neutral gray (85) crest-olive brown (28) & light drab (119C)-dark drab (119B) crest-grayish horn (91)-drab (27)-cinnamon (39)-clay (26)-pale neutral gray (86) crest-drab gray (119D)-tawny (38) crest-medium plumbeous (87) crest-cinnamon (123A) crest-mikado brown (121C) & ground cinnamon (239) crest-drab (27) crest-light drab (119C) crest-dark drab (119B)-sayal brown (223C)	Cinnamon (123A) shaft-raw sienna (136) shaft

Appendix 5 Continued.

Age Category/ Body Region	Species (n)	Background coloration	Pattern
YEARLING/ ADULT FEMALE Back	Cabots (12)	Jet black (89)-black-Vandyke brown (121)	Pale horn (92) ocellus with buff (124) & raw sienna (136) vermiculations-white ocellus with buff yellow (53), cream (54), trogon yellow (153), kingfisher rufous (240) & cinnamon (39) vermiculations-chamois (123D), yellow ocher (123C), cinnamon (123A) & smoke gray (44) vermiculations-clay (123B & 26) vermiculations-antique brown (37) & tawny (38) vermiculations-sayal brown (223C), tawny olive (223D) & mikado brown (121C) vermiculations
	Satyr (20)	Vandyke brown (121)-jet black (89)-dull black-black	Chamois (123D), yellow ocher (123C), cream (54) & white vermiculations-warm buff (118) & buff yellow (53) vermiculations-dull white ocellus with buff (124) vermiculations-raw sienna (136)& cinnamon (123A) vermiculations-white shaft with warm buff (118) ocellus-chamois (123D) ocellus with clay (123B & 26) & antique brown (37) vermiculations-buff (124) ocellus-pale neutral gray (86) vermiculations-cream (54) ocellus-pale horn (92) ocellus-cinnamon (39) & pale horn (92) vermiculations tipped with dark drab (119B) & light drab (119C)-tawny (38), mikado brown (121C) & sayal brown (223C) vermiculations-pale neutral gray (86) vermiculations

Appendix 5 Continued.

Age Category/ Body Region	Species (n)	Background coloration	Pattern
YEARLING/ ADULT FEMALE Back	Temminck's (59)	Jet black (89)-black-dull black	White ocellus with warm buff (118) vermiculations-buff (124) & clay (123B) vermiculations with pale horn (92) ocellus-raw sienna (136), cinnamon (123A) & yellow ocher (123C) vermiculations-clay (123B), trogon yellow (153), mikado brown (121C) & cinnamon (39) vermiculations-antique brown (37) vermiculations-pale horn (92) & smoke gray (44) vermiculations-raw sienna (136) tip-chamois (123D) & tawny (38) vermiculations-pale neutral gray (86) vermiculations-raw umber (123) vermiculations-clay (26) vermiculations
	Blyth's (20)	Dull black-black	Warm buff (118) & buff yellow (53) vermiculations with cream (54) ocellus-cinnamon (123A) & clay (123B) vermiculations-buff (124) vermiculations-yellow ocher (123C) & trogon yellow (153) vermiculations-chamois (123D) ocellus-pale horn (92) ocellus with pale neutral gray (86) vermiculations-warm buff (118) ocellus-buff (124) ocellus-smoke gray (44) vermiculations at tip-cinnamon (39), tawny (38) & raw sienna (136) vermiculations-clay (26) & antique brown (37) vermiculations
	Western (5)	Black	Black ocellus with white shaft bordered by clay (123B) & pale horn (92) with pale horn (92), clay (123B) & smoke gray (44) vermiculations-white ocellus bordered with black-smoke gray (45) & clay (26) vermiculations

Appendix 5 Continued.

Age Category/ Body Region	Species (n)	Background coloration	Pattern
YEARLING/ ADULT FEMALE Back	Blood (132)	Vandyke brown (121)-dull black-hair brown (119A)	Fine pale neutral gray (86) vermiculations-fine clay (26) vermiculations-fine cinnamon (123A) vermiculations-cinnamon (39) vermiculations-yellow ocher (123C) & chamois (123D) vermiculations-drab gray (119D) vermiculations-white vermiculations-cinnamon drab (219C) & fawn (25) vermiculations-drab (27) & tawny olive (223D) vermiculations-Prout's brown (121A) vermiculations-sayal brown (223C) & ground cinnamon (239) vermiculations-antique brown (37) vermiculations-light drab (119C) & cinnamon brown (33) vermiculations-medium neutral gray (84) vermiculations-pale pinkish buff (121D) vermiculations-light neutral gray (85) vermiculations-verona brown (223B)-pale horn (92) vermiculations
Rump	Cabots (12)	Jet black (89)-black-Vandyke brown (121)	Shaft pale horn (92) with buff (124) & raw sienna (136) vermiculations-buff yellow (53), cream (54), trogon yellow (153), kingfisher rufous (240) & cinnamon (39) vermiculations-white ocellus with chamois (123D), yellow ocher (123C), cinnamon (123A) & smoke gray (44) vermiculations-clay (123B & 26) vermiculations-antique brown (37) & tawny (38) vermiculations-sayal brown (223C), tawny olive (223D) & mikado brown (121C) vermiculations

Appendix 5 Continued.

Age Category/ Body Region	Species (n)	Background coloration	Pattern
YEARLING/ ADULT FEMALE Rump	Satyr (20)	Vandyke brown (121)-jet black (89)-dull black-black	Chamois (123D), yellow ocher (123C), cream (54) & white vermiculations-buff (24) & trogon yellow (153) vermiculations-chamois (123D) ocellus with cinnamon (123A) & antique brown (37) vermiculations-clay (123B) & raw sienna (136) vermiculations-dull black ocellus-pale horn (92) ocellus-buff (124) ocelli-pale neutral gray (86) vermiculations towards tip-cream (54) ocellus-warm buff (118)-pale horn (92) vermiculations-tawny (38), cinnamon (39), mikado brown (121C) & sayal brown (223C) vermiculations-clay (26) vermiculations
	Temminck's (59)	Jet black (89)-black-dull black	Warm buff (118) vermiculations-dull white ocellus with buff (124), clay (123B), buff (24), pale horn (92), smoke gray (44) & pale neutral gray (86) bands & vermiculations-yellow ocher (123C) & cream (54) vermiculations-antique brown (37), cinnamon (39), mikado brown (121C), trogon yellow (153), cinnamon (123A) & clay (26) vermiculations-raw sienna (136) tip-tawny (38) & raw sienna (136) vermiculations-pale horn (92) ocellus-chamois (123D) vermiculations-chamois (123D) ocellus-raw umber (123) vermiculations-smoke gray (45)

Appendix 5 Continued.

Age Category/ Body Region	Species (n)	Background coloration	Pattern
YEARLING/ ADULT FEMALE Rump	Blyth's (20)	Dull black-black	Cinnamon rufous (40) vermiculations-buff (124) & warm buff (118) vermiculations-cream (54) ocelli with clay (123B) & buff (24) vermiculations-yellow ocher (123C) vermiculations-cinnamon (123A & 39) & antique brown (37) vermiculations-pale horn (92) ocellus with pale neutral gray (86) vermiculations-chamois (123D) vermiculations-smoke gray (44) vermiculations towards tip-buff (124) ocellus-chamois (123D) ocellus-white ocellus with tawny (38) & raw sienna (136) vermiculations
	Western (5)	Black	Black ocellus and white shaft with clay (123B), pale horn (92) & smoke gray (44) vermiculations-white ocellus-smoke gray (45) & clay (26) vermiculations
	Blood (132)	Vandyke brown (121)-dull black-hair brown (119A)-black	Fine pale neutral gray (86) vermiculations-clay (26) vermiculations-cinnamon (123A) vermiculations-cinnamon (39) vermiculations-yellow ocher (123C) & chamois (123D) vermiculations-drab gray (119D) vermiculations-cinnamon drab (219C), fawn (25) & white vermiculations-drab (27) & tawny olive (223D) vermiculations-Prout's brown (121A) vermiculations-sayal brown (223C) & ground cinnamon (239) vermiculations-antique brown (37) vermiculations-light drab (119C) & cinnamon brown (33) vermiculations-cinnamon (123A) vermiculations-medium neutral gray (84) vermiculations-pale pinkish buff (121D) vermiculations-light neutral gray (85)-verona brown (223B) vermiculations

Appendix 5 Continued.

Age Category/ Body Region	Species (n)	Background coloration	Pattern
YEARLING/ ADULT FEMALE Upper Wing Coverts	Cabots (12)	Jet black (89)-black-dull black	Amber (36) & cinnamon (39) vermiculations with a buff (124) ocellus-white ocellus with buff yellow (53), yellow ocher (123C), raw sienna (136), buff (124), warm buff (118) & tawny (38) vermiculations-clay (123B) & chamois (123D) vermiculations-chamois (123D) ocellus & cinnamon (123A) vermiculations-white ocellus-pale horn (92) ocellus & vermiculations
	Satyr (20)	Jet black (89)-dull black-black	Orange rufous (132C) & warm buff (118) vermiculations-cream (54) ocellus with cinnamon (123A) & clay (123B) vermiculations-trogon yellow (153), yellow ocher (123C) & clay (26) vermiculations-tawny (38) vermiculations-warm buff (118) ocellus with raw sienna (136) & cinnamon (39) vermiculations-cinnamon rufous (40) vermiculations-buff (124) ocellus-chamois (123D) ocellus-pale horn (92) ocellus-true cinnamon (139), verona brown (223B), sayal brown (223C) & antique brown (37) vermiculations-chamois (123D) vermiculations-tawny olive (223D) vermiculations-tawny (38) ocellus with amber (36) vermiculations

Appendix 5 Continued.

Age Category/ Body Region	Species (n)	Background coloration	Pattern
YEARLING/ ADULT FEMALE Upper Wing Coverts	Temminck's (59)	Dull black-black	White ocellus with amber (36) vermiculations-chamois (123D) ocellus with cinnamon (123A), warm buff (118) & cinnamon (39) vermiculations-buff (124), chamois (123D) & clay (26) vermiculations-antique brown (37), trogon yellow (153) & raw sienna (136) vermiculations-mikado brown (121C) vermiculations-pale horn (92) ocellus with cinnamon (123A), clay (123B), yellow ocher (123C) & raw umber (23) vermiculations-buff yellow (53) vermiculations-cream (54) ocellus-tawny (38) vermiculations-buff (124) ocellus-cream (54) & antique brown (37) vermiculations-mikado brown (121C) vermiculations-cinnamon (39) ocellus
	Blyth's (20)	Dull black-jet black (89)-black	Cream (54) ocellus with raw sienna (136) & buff (124) vermiculations-chamois (123D) ocellus with clay (123B), yellow ocher (123C) & cinnamon (123A) vermiculations-chamois (123D) & raw sienna (136) vermiculations-warm buff (118) vermiculations-trogon yellow (153) ocellus-trogon yellow (153) vermiculations-buff (124) ocellus-tawny (38) vermiculations-cinnamon (39) vermiculations-warm buff (118) ocellus-pale horn (92) ocellus-antique brown (37) vermiculations
	Western (5)	Prout's brown (121A)-black-dull black	White ocellus with yellow ocher (123C) & chamois (123D) vermiculations-chamois (123D) & pale horn (92) ocellus with tawny (38), cinnamon (39) & buff (124) vermiculations-tawny olive (223D) vermiculations-pale horn (92) ocellus with smoke gray (45) & clay (26) vermiculations

Appendix 5 Continued.

Age Category/ Body Region	Species (n)	Background coloration	Pattern
YEARLING/ ADULT FEMALE Upper Wing Coverts	Blood (132)	Vandyke brown (121)-dull black-hair brown (119A)-Prout's brown (121A)	Fine pale neutral gray (86) vermiculations-clay (26) vermiculations-cinnamon (123A) vermiculations-cinnamon (39), yellow ocher (123C) & chamois (123D) vermiculations-drab gray (119D) vermiculations-cinnamon drab (219C), fawn (25) & white vermiculations-drab (27) & tawny olive (223D) vermiculations-Prout's brown (121A) vermiculations-sayal brown (223C) & ground cinnamon (239) vermiculations-antique brown (37) vermiculations-light drab (119C) vermiculations-cinnamon brown (33) vermiculations-pale pinkish buff (121D) vermiculations-light neutral gray (85)-verona brown (223B) vermiculations-pale horn (92) vermiculations
Rectrices	Cabots (12)	Jet black (89)	Amber (36) & cinnamon (39) vermiculations & discontinuous bars-tawny (38), raw sienna (136), black, cinnamon (123A) & white vermiculations & discontinuous bars-band of ground cinnamon (239) with pale horn (92) vermiculations-raw umber (23) bands-verona brown (223B), sayal brown (223C), tawny olive (223D), Prout's brown (121A), Brussel's brown (121B), mikado brown (121C), antique brown (37), clay (26) & cinnamon brown (33) mottling-pale pinkish buff (121D) mottling

Appendix 5 Continued.

Age Category/ Body Region	Species (n)	Background coloration	Pattern
YEARLING/ ADULT FEMALE Rectrices	Satyr (20)	Vandyke brown (221)-jet black (89)-Prout's brown (121A)-russet (34)	Cream (54), pale horn (92), Brussel's brown (121B), mikado brown (121C), raw umber (23), light drab (119C), verona brown (223B) & tawny (38) vermiculations forming discontinuous bars-warm buff (118) vermiculations-tawny olive (223D) vermiculations-antique brown (37), cinnamon (39), Prout's brown (121A) & sayal brown (223C) bars-white ocellus at tip-true cinnamon (139) bars-cinnamon brown (33) bands-ground cinnamon (239) bands
	Temminck's (59)	Dull black	Mikado brown (121C), Brussel's brown (121B), cinnamon (39), raw umber (23), verona brown (223B), chamois (123D), buff (124) & cinnamon brown (33) mottling-tawny olive (223D) bands-vermiculated raw sienna (136) bands-black & antique brown (37) vermiculations-sayal brown (223C) & Prout's brown (121A) vermiculations-cinnamon brown (33) & clay (26) bands-russet (34) mottling-pale pinkish buff (121D) band with white ocellus towards tip-true cinnamon (139) mottling-ground cinnamon (239), tawny olive (223D) & fawn (25) vermiculations-burnt umber (22) vermiculated bands-natal brown (219A) & Mar's brown (223A) vermiculated bands-light drab (119C) vermiculated bands

Appendix 5 Continued.

Age Category/ Body Region	Species (n)	Background coloration	Pattern
YEARLING/ ADULT FEMALE Rectrices	Blyth's (20)	Dull black-black	Raw sienna (136) & buff (124) vermiculations forming incomplete bands-verona brown (223B), clay (26), raw umber (23) & cinnamon (39) vermiculations-jet black (89) bands-cinnamon (123A) & antique brown (37) vermiculations with white ocellus at tip-Prout's brown (121A) & pale pinkish buff (121D) bands-mikado brown (121C) bands-fuscous (21), Brussel's brown (121B), sayal brown (223C), tawny olive (223D) & true cinnamon (139) bands-russet (34) & Mar's brown (223A) bands-burnt umber (22) & cinnamon brown (33) bands
	Western (5)	Dull black-black	White, pale neutral gray (86) & sayal brown (223C) vermiculations-fine tawny olive (223D) & light drab (119C) vermiculations
	Blood (132)	Vandyke brown (221)-black-hair brown (119A)-Vandyke brown (121)-dull black-Prout's brown (121A)	Fine pale neutral gray (86) vermiculations-pale horn (92) mottling-tawny olive (223D) mottling-cream (54) mottling-smoke gray (44) mottling-sayal brown (223C) mottling-cinnamon (39) mottling-drab gray (119D) & Vandyke brown (121) mottling-pearl gray (81) & white vermiculations-cinnamon drab (219C) & fawn (25) mottling-drab (27) vermiculations-yellow ocher (123C) & chamois (123D) mottling-cinnamon (123A) vermiculations-clay (123B) vermiculations-ruby (10), vinaceous pink (221C) & light russet vinaceous (221D) edges-pale pinkish buff (121D) vermiculations-light neutral gray (85) mottling-vinaceous (3) edges-clay (26) vermiculations-spinel red (108B) edges

Appendix 5 Continued.

Age Category/ Body Region	Species (n)	Background coloration	Pattern
YEARLING/ ADULT FEMALE Throat	Cabots (12)	Dull white tinged with yellow ocher (123C)-tinged with warm buff (118)	Pale horn (92) ocellus edged with buff (124) & jet black (89)-ocellus edged with salmon (6)-dull black wedges on sides
	Satyr (20)	Dull white tinged with warm buff (118)-tinged with cinnamon rufous (40)-pale horn (92)-tinged with cinnamon (39)-tinged with buff (124)	Buff yellow (53) & dull black edges-pale horn (92) center with warm buff (118) tip
	Temminck's (59)	Buff (124)-dull white-tinged with buff yellow (53) & yellow ocher (123C)-chamois (123D) & warm buff (118)-tinged with clay (123B)-pale horn (92)	Edged with dull black & warm buff (118)-buff (124) edges
	Blyth's (20)	Dull white-warm buff (118)	Dull black wedges-tipped with pale horn (92)-buff (124) tip-tipped with warm buff (118)
	Western (5)	Dull white-tinged with warm buff (118)-pale horn (92)	Raw sienna (136) & verona brown (223B) edges-black edges
	Blood (132)	Yellow ocher (123C)-cinnamon (123A) tinged with crimson (108)-tinged with antique brown (37)-cinnamon (39) tinged with tawny (38)-tinged with raw sienna (136)-clay (123B)-clay (26)-grayish horn (91) & dark drab (119B)-light drab (119C)-buff (124)-pale neutral gray (86)-drab (27)-drab gray (119D)-tinged with Pratt's rufous (140)-light neutral gray (85)-tawny olive (223D)-mahogany red (132B)-mikado brown (121C)	Edged with medium plumbeous (87)

Appendix 5 Continued.

Age Category/ Body Region	Species (n)	Background coloration	Pattern
YEARLING/ ADULT FEMALE Breast	Cabots (12)	Jet black (89)-black-Vandyke brown (121)	Lanceolate pale horn (92) ocellus with amber (36) vermiculations-tawny (38) & cinnamon (39) vermiculations with dull white ocellus-raw sienna (136), buff (124) & yellow ocher (123C) vermiculations-pale horn (92) & chamois (123D) vermiculations-warm buff (118) & trogon yellow (153) vermiculations-tawny olive (223D) & pale pinkish buff (121D) vermiculations-clay (26 & 123B) & cinnamon (123A) vermiculations
	Satyr (20)	Blackish neutral gray (82)-dull black-hair brown (119A) & olive brown (28)-black-Prout's brown (121A)	Dull white ocellus with yellow ocher (123C), chamois (123D) & warm buff (118) vermiculations-pale horn (92) ocellus with buff (124) vermiculations-raw sienna (136) & clay (26) vermiculations-cream (54) ocellus with white shaft & buff yellow (53), cinnamon (123A) & clay (123B) vermiculations-lanceolate chamois (123D) ocellus with cinnamon (39) vermiculations-cream (54) vermiculations-tawny (38) vermiculations-mikado brown (121C), antique brown (37), sayal brown (223C) & tawny olive (223D) vermiculations-amber (36) vermiculations-buff (124) ocellus

Appendix 5 Continued.

Age Category/ Body Region	Species (n)	Background coloration	Pattern
YEARLING/ ADULT FEMALE Breast	Temminck's (59)	Jet black (89)-Vandyke brown (121)-black	White ocellus with warm buff (118) vermiculations-yellow ocher (123C) & chamois (123D) vermiculations-cream (54) vermiculations-clay (123B) vermiculations-warm buff (118) & cinnamon (39) vermiculations-buff yellow (53) vermiculations-cream (54) ocellus-cinnamon (123A) tip & trogon yellow (153) vermiculations-tawny (38) vermiculations-cinnamon (123A) vermiculations-raw sienna (136) vermiculations-chamois (123D) ocellus with amber (36) & mikado brown (121C) vermiculations-pale neutral gray (86) vermiculations-buff (124) vermiculations-tawny olive (223D) vermiculations-antique brown (37) vermiculations
	Blyth's (20)	Vandyke brown (121)-dull black	Dull white ocellus with pale pinkish buff (121D) vermiculations-trogon yellow (153) vermiculations-yellow ocher (123C), buff yellow (53) & clay (26) vermiculations-pale horn (92), cream (54) & buff (124) vermiculations-trogon yellow (153) vermiculations-chamois (123D) vermiculations-warm buff (118) vermiculations-tawny olive (223D) vermiculations-clay (123B) vermiculations-pale horn (92) ocellus with cinnamon (39 & 123A) vermiculations-sayal brown (223C) vermiculations-mikado brown (121C) vermiculations
	Western (5)	Raw umber (23)-dull black	White ocellus along shaft & white ocellus towards tip bordered by black-finely vermiculated with smoke gray (44)-finely vermiculated with clay (123B) & dull white-clay (26) vermiculations

Appendix 5 Continued.

Age Category/ Body Region	Species (n)	Background coloration	Pattern
YEARLING/ ADULT FEMALE Breast	Blood (132)	Fawn (25)-antique brown (37)-cinnamon (39)-Vandyke brown (121)-dull black-hair brown (119A)-sayal brown (223C) & clay (26)-ground cinnamon (239) & drab (27)-cinnamon brown (33)-raw umber (23)-verona brown (223B) tinged with mikado brown (121C)-tawny olive (223D)-true cinnamon (139)-tinged with vinaceous pink (221C)-Brussel's brown (121B)-pale neutral gray (86)-tinged with vinaceous (4)-tinged with light drab (119C)-russet (34)-cinnamon (123A)-tawny (38)-tinged with vinaceous (3)-raw umber (23)	Fine sepia (219) vermiculations-white shaft-cinnamon (39), yellow ocher (123C) & chamois (123D) vermiculations-drab gray (119D) vermiculations-cinnamon drab (219C), fawn (25) & white vermiculations-black vermiculations-cinnamon (123A) & brick red (132A) vermiculations-chamois (123D) shaft-Vandyke brown (121) vermiculations-sayal brown (223C) vermiculations-cinnamon (39) shaft
Belly	Cabots (12)	Pale horn (92) edged with cinnamon brown (33)-dull black-black	Buff (124) & olive brown (28) vermiculations-white ocellus-tawny olive (223D) vermiculations-warm buff (118) & pale pinkish buff (121D) vermiculations-tawny (38), clay (26 & 123B), raw sienna (136), cinnamon (123A), yellow ocher (123C) & chamois (123D) vermiculations-fine cinnamon (39) & pale horn (92) vermiculations
	Satyr (20)	Blackish neutral gray (82)-buff (124)-Vandyke brown (121)-dull black-black-Prout's brown (121A)	White ocellus with yellow ocher (123C), chamois (123D) & warm buff (118) vermiculations-pale horn (92) ocellus-dull black vermiculations-ocellus bordered with Vandyke brown (121) with buff (124) & raw sienna (136) vermiculations-cinnamon (123A) & clay (123B) vermiculations-lanceolate chamois (123D) ocellus with cinnamon (39) vermiculations-tawny olive (223D) vermiculations-pale horn (92) vermiculations-tawny (38) vermiculations-clay (26), mikado brown (121C), antique brown (37) & sayal brown (223C) vermiculations-amber (36) vermiculations

Appendix 5 Continued.

Age Category/ Body Region	Species (n)	Background coloration	Pattern
YEARLING/ ADULT FEMALE Belly	Temminck's (59)	Jet black (89)-dull black-Vandyke brown (121)-black	White ocellus with warm buff (118) vermiculations-chamois (123D) vermiculations-buff (124) & yellow ocher (123C) vermiculations-tawny olive (223D) & cinnamon (39) vermiculations-pale horn (92) ocellus-tipped with cinnamon (123A)-buff yellow (53) & trogon yellow (153) vermiculations-clay (123B) vermiculations-tawny (38) vermiculations-raw sienna (136) vermiculations-tawny olive (223D) vermiculations-antique brown (37) vermiculations
	Blyth's (20)	Dull white-Vandyke brown (121)-dull black	White ocellus with trogon yellow (153) vermiculations-cream (54) & buff (124) vermiculations-yellow ocher (123C) & white vermiculations-chamois (123D) vermiculations-pale horn (92) & cinnamon (39) vermiculations-tawny olive (223D) vermiculations-pale pinkish buff (121D) vermiculations-warm buff (118) vermiculations-pale horn (92) ocellus with clay (26) & cinnamon (123A) vermiculations-sayal brown (223C) vermiculations-clay (123B) vermiculations-mikado brown (121C) vermiculations
	Western (5)	Raw umber (23)-dull black	White ocellus-ocellus bordered with black & with clay (123B), white & smoke gray (44) vermiculations-clay (26) vermiculations

Appendix 5 Continued.

Age Category/ Body Region	Species (n)	Background coloration	Pattern
YEARLING/ ADULT FEMALE Belly	Blood (132)	Fawn (25)-antique brown (37)-cinnamon (39)-Vandyke brown (121)-hair brown (119A)-sayal brown (223C), tawny olive (223D) & ground cinnamon (239)-drab (27)-cinnamon brown (33)-raw umber (23)-verona brown (223B) tinged with mikado brown (121C)-Brussel's brown (121B)-clay (26)-pale neutral gray (86)-tinged with deep vinaceous (4)-russet (34)-light drab (119C)-tawny (38)	Fine sepia (219) vermiculations-white shaft-black mottling-cinnamon (39), yellow ocher (123C) & chamois (123D) vermiculations-drab gray (119D) vermiculations-cinnamon drab (219C), fawn (25) & white vermiculations-drab (27) & tawny olive (223D) vermiculations-black vermiculations-fine cinnamon (123A) vermiculations-chamois (123D) shaft-pale horn (92) vermiculations-sayal brown (223C) & ground cinnamon (239) vermiculations-Vandyke brown (121) vermiculations-cinnamon (39) shaft
Crissum	Cabots (12)	Cinnamon (39) & tawny (38)	Lanceolate cream (54) ocellus with jet black (89) vermiculations-white ocellus with buff (124) & yellow ocher (123C) vermiculations-tawny olive (223D) & cinnamon (39) vermiculations-mikado brown (121C) & sayal brown (223C) vermiculations
	Satyr (20)	Buff (124), chamois (123D) & cinnamon (123A)-dull black-black	Buff (124) ocellus with black vermiculations-white ocellus bordered with dull black-sayal brown (223C), raw umber (23) & clay (26) vermiculations-pale horn (92) ocellus with raw sienna (136), tawny olive (223D) & antique brown (37) vermiculations-lanceolate chamois (123D) ocellus with chamois (123D), cinnamon (39) & warm buff (118) vermiculations-cinnamon (123A) & mikado brown (121C) vermiculations-cream (54) vermiculations-sayal brown (223C) vermiculations-tawny (38) vermiculations

Appendix 5 Continued.

Age Category/ Body Region	Species (n)	Background coloration	Pattern
YEARLING/ ADULT FEMALE Crissum	Temminck's (59)	Dull black-black	White ocellus with mikado brown (121C), antique brown (37) & cinnamon (39) vermiculations-cinnamon (123A) vermiculations-cream (54) ocellus with chamois (123D) & buff (124) vermiculations-alternating black, mikado brown (121C) & verona brown (223B) vermiculations-warm buff (118) & tawny olive (223D) vermiculations-yellow ocher (123C) bands-sayal brown (223C) mottling-clay (123B) vermiculations-sayal brown (223C) vermiculations-tawny (38) vermiculations-pale pinkish buff (121D) vermiculations
	Blyth's (20)	Dull black-black	Raw sienna (136) & buff (124) vermiculations with cream (54) ocellus-white ocellus with cinnamon (123A) & yellow ocher (123C) vermiculations-warm buff (118) vermiculations-clay (26) & cream (54) vermiculations-antique brown (37) & cinnamon (39) vermiculations-tawny olive (223D) vermiculations-mikado brown (121C), clay (123B) & chamois (123D) vermiculations-sayal brown (223C) vermiculations-verona brown (223B) vermiculations
	Western (5)	Hair brown (119A)-black	White ocellus bordered by black with pale horn (92), tawny olive (223D) & pale pinkish buff (121D) vermiculations-cinnamon (39) vermiculations-sayal brown (223C) vermiculations

Appendix 5 Continued.

Age Category/ Body Region	Species (n)	Background coloration	Pattern
YEARLING/ ADULT FEMALE Crissum	Blood (132)	Vandyke brown (121)-dull black-hair brown (119A)-Prout's brown (121A)	Fine pale neutral gray (86) vermiculations-clay (26) vermiculations-cinnamon (123A) vermiculations-cinnamon (39), yellow ocher (123C) & chamois (123D) vermiculations-drab gray (119D) vermiculations-cinnamon drab (219C), fawn (25) & white vermiculations-drab (27) & tawny olive (223D) vermiculations-Prout's brown (121A) vermiculations-sayal brown (223C) & ground cinnamon (239) vermiculations-antique brown (37) vermiculations-light drab (119C) vermiculations-cinnamon brown (33) vermiculations-pale pinkish buff (121D) vermiculations-light neutral gray (85)-verona brown (223B) vermiculations-pale horn (92) vermiculations