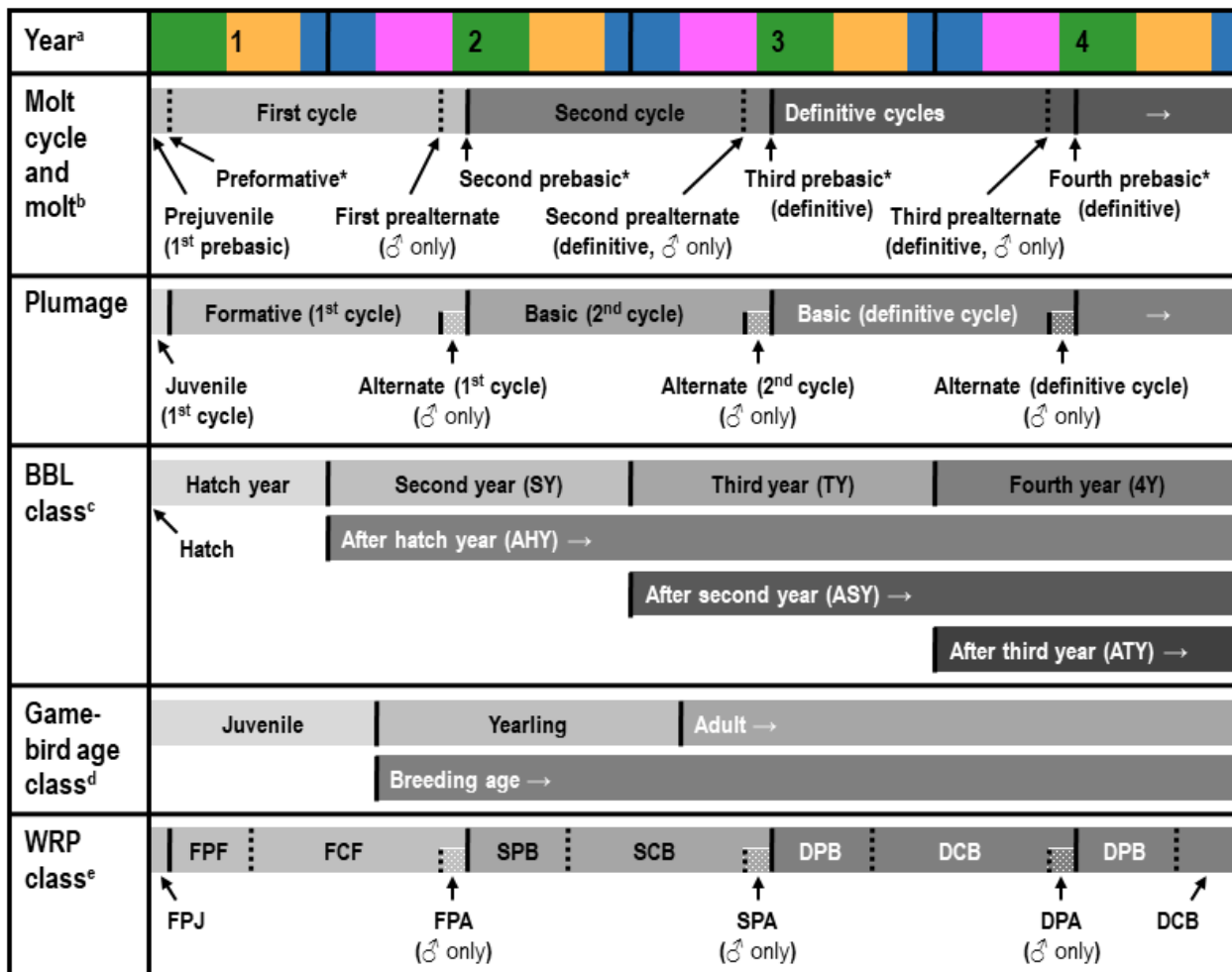


Walker, B. L. and M. A. Schroeder. 2021. Atypical primary molt patterns in greater sage-grouse: implications for age classification. – Wildlife Biology 2021: wlb.00855.

Appendix 1

Figure A1. Molt cycles, molts, and plumages in greater sage-grouse in relation to calendar year, season, and three age classification systems currently in use in North America.



^a Breaks between calendar years occur on 31 Dec/1 Jan. Season: green = summer (Jun-Aug), orange = autumn (Sep-Nov), blue = winter (Dec-Feb), pink = spring (Mar-May).

^b Molt cycles and molts. Birds enter the next molt cycle when molt begins. Asterisks indicate molts during which atypical molt occurs. We show the approximate start date of each molt. The duration of preformative and prebasic molts is typically 4 months. Prealternate molt only occurs in males and only includes body feathers (Pyle 2007).

^c Bird Banding Laboratory (BBL) calendar-based age codes. Hatch year code is HY.

^d Calendar-based age classes commonly used in North American gamebird studies. We show the calendar date on which birds transition to the next age class (typically defined as the start of the breeding season) as 1 March each year, but it varies among studies from 1 January to 15 April.

^e Wolfe-Ryder-Pyle (WRP) classes for greater sage-grouse: FPJ = molting into first-cycle juvenile plumage, FPF = molting into first-cycle formative plumage, FCF = first-cycle formative plumage,

FPA = molting into first-cycle alternate plumage (males only), SPB = molting into second-cycle basic plumage, SCB = second-cycle basic plumage, SPA = molting into second-cycle alternate plumage (males only), DPB = molting into definitive-cycle basic plumage, DCB = definitive-cycle basic plumage, DPA = molting into definitive-cycle alternate plumage (males only) (Wolfe et al. 2010, Johnson et al. 2011). We do not show first-cycle juvenile (FCJ) plumage or first-, second-, or definitive-cycle alternate plumages (FCA, SCA, and DCA, respectively) because, in greater sage-grouse, preformative molt begins before prejuvenal molt is finished (Beck et al. 1975) and prebasic molt in males begins before prealternate body molt has finished (Pyle 2007).

Table A1. Atypical outer primary patterns documented in greater sage-grouse in five U.S. states, 2003-2020. Birds with an asterisk are known-aged individuals based either on capture history or multiple plumage and morphological characteristics. Age classes listed for all other birds were determined based on primary appearance.

Bird ID	Sex	Status	Date	Location	Primary (P) appearance ^a						BBL age ^c	Molt cycle ^d	WRP class ^e	Photo
					P5	P6	P7	P8	P9 ^b	P10 ^b				
Atypical outer primary retention (following prebasic molt)														
F1505*	F	Captured	08 Apr 2012	Rio Blanco Co., CO	N	N	N	N	RO	RO	A4Y	D	DCB	Fig. 2A
M94/1047 ^f	F	Captured	18 Apr 2003	Bighorn Co., MT	N	N	N	N	RN	RO	ATY (TY?)	D (2 nd ?)	DCB (SCB?)	No
P77/1107 ^f	F	Captured	06 Apr 2004	Bighorn Co., MT	N	N	N	O	RO	RO	ATY (TY?)	D (2 nd ?)	DCB (SCB?)	Fig. 2B
1167 ^f	F	Captured	26 Mar 2006	Bighorn Co., MT	N	N	N	N	RN	RO	ATY (TY?)	D (2 nd ?)	DCB (SCB?)	No
1180 ^f	F	Captured	30 Mar 2006	Bighorn Co., MT	N	N	N	N	RN	RO	ATY (TY?)	D (2 nd ?)	DCB (SCB?)	No
1114 ^f	F	Captured	17 Mar 2015	Lake Co., OR	N	N	N	N	RN	RO	ATY (TY?)	D (2 nd ?)	DCB (SCB?)	No
MAS0400 ^{fg}	F	Harvested	08 Sep 2012	Lake Co., OR	N	O	O	O	RO	RO	ASY (SY?)	D (2 nd ?)	DCB (SCB?)	Yes
MAS0401 ^f	F	Harvested	09 Sep 2012	Lake Co., OR	N	N	O	O	RO	RO	ASY (SY?)	D (2 nd ?)	DCB (SCB?)	Fig. 2C
2140*	M	Captured	29 Apr 2020	Douglas Co., WA	N	N	N	N	RN	PO	TY	2 nd	SCB	No
M3536*	M	Captured	12 Mar 2013	Sweetwater Co., WY	N	N	N	N	RN	PO	TY	2 nd	SCB	Fig. 2D, E
Atypical outer primary replacement (following preformative molt)														
2107*	M	Captured	07 Apr 2016	Douglas Co., WA	N	N	N	N	RN	PO	SY	1 st	FCF	Fig. 2F
M3125*	M	Captured	13 Mar 2011	Moffat Co., CO	N	N	N	N	RN/PO	PO	SY	1 st	FCF	No
Atypical outer primary replacement or retention														
A82/1099 ^h	F	Captured	25 Mar 2004	Johnson Co., WY	N	N	N	N	RN	PO	SY or TY	1 st or 2 nd	FCF or SCB	Fig. 2G
P95/1104	F	Captured	29 Mar 2004	Bighorn Co., MT	N	N	N	N	RN	PO/RN	SY or TY	1 st or 2 nd	FCF or SCB	No
P75/1111	F	Captured	07 Apr 2004	Bighorn Co., MT	N	N	N	N	RN	PO	SY or TY	1 st or 2 nd	FCF or SCB	No
F1448	F	Captured	17 Nov 2008	Rio Blanco Co., CO	~	~	~	~	RN	PO	SY or TY	1 st or 2 nd	FCF or SCB	No
F1568	F	Captured	07 Dec 2008	Rio Blanco Co., CO	~	~	~	~	RN	PO	SY or TY	1 st or 2 nd	FCF or SCB	No
F1654	F	Captured	14 Dec 2007	Moffat Co., CO	~	~	~	~	RN	PO	SY or TY	1 st or 2 nd	FCF or SCB	No
Unmarked A	F	Harvested	16 Sep 2019	Moffat Co., CO	N	G	G	O	RO	PO	SY or TY	2 nd or 3 rd	SPB or TPB	Yes
Unmarked B	F	Harvested	17 Sep 2019	Moffat Co., CO	N	G	O	O	RO	PO	SY or TY	2 nd or 3 rd	SPB or TPB	Yes
Unmarked C	F	Harvested	25 Sep 2019	Moffat Co., CO	N	N	G	O	RO	PO	SY or TY	2 nd or 3 rd	SPB or TPB	Yes
Unmarked D	F	Harvested	09 Sep 2017	Lake Co., OR	N	G	G	O	RO	PO	SY or TY	2 nd or 3 rd	SPB or TPB	Fig. 2H
F1840	F	Captured	22 Apr 2009	Sweetwater Co., WY	N	N	N	N	RN	PO	SY or TY	1 st or 2 nd	FCF or SCB	No

Table A1 (cont.). Atypical outer primary patterns documented in greater sage-grouse in five U.S. states, 2003-2020. Birds with an asterisk are known-aged individuals based either on capture history or multiple plumage and morphological characteristics. Age classes listed for all other birds were determined based only on primary appearance.

Bird ID	Sex	Status	Date	Location	Primary (P) appearance ^a					BBL age ^c	Molt cycle ^d	WRP class ^e	Photo	
					P5	P6	P7	P8	P9 ^b					P10 ^b
Atypical outer primary replacement or retention (cont.)														
1006	F	Captured	25 Mar 2012	Lake Co., OR	N	N	N	N	RN	RN/PO	SY or TY	1 st or 2 nd	FCF or SCB	No
1013	F	Captured	26 Mar 2012	Lake Co., OR	N	N	N	N	RN	PO	SY or TY	1 st or 2 nd	FCF or SCB	No
MAS0395	F	Harvested	09 Sep 2012	Harney Co., OR	N	N	G	G	RO	PO	SY or TY	2 nd or 3 rd	SPB or TPB	Yes
MAS0396	F	Harvested	09 Sep 2012	Malheur Co., OR	N	N	N	G	RO	PO	SY or TY	2 nd or 3 rd	SPB or TPB	Yes
1016	F	Captured	28 Mar 2012	Harney Co., OR	N	N	N	N	RN	PO	SY or TY	1 st or 2 nd	FCF or SCB	No
1017	F	Captured	27 Mar 2012	Harney Co., OR	N	N	N	N	RN	PO	SY or TY	1 st or 2 nd	FCF or SCB	No
951	F	Captured	30 Mar 2011	Malheur Co., OR	N	N	N	N	RN	PO	SY or TY	1 st or 2 nd	FCF or SCB	No
1131	F	Captured	20 Mar 2015	Harney Co., OR	N	N	N	N	RN	PO	SY or TY	1 st or 2 nd	FCF or SCB	No

^a Primaries are described as: “N” = relatively new (completely grown, darker gray-brown, with less wear), “O” = relatively old (completely grown, lighter brown, with more wear), “R” = rounded tip (typical of formative and basic primaries), “P” = pointed tip (typical of juvenile primaries), and “G” = actively growing. Tip shapes of P5-P8 and growing feathers are not described because they were all rounded (i.e., formative or basic primaries). Feathers not described are listed as “~”.

^b When primaries were asymmetric, we list appearance as right wing/left wing. Data from harvested birds are based on only one wing.

^c Bird Banding Laboratory age classes: HY = hatch year, SY = second year, TY = third year, ASY = after second year, ATY = after third year, A4Y = after fourth year.

^d Molt cycle: 1st = first cycle, 2nd = second cycle, 3rd = third cycle, D = definitive cycle.

^e Wolfe-Ryder-Pyle (WRP) age classes: FCF = first-cycle formative plumage, SPB = molting into second-cycle basic plumage, SCB = second-cycle basic plumage, DPB = molting into definitive cycle-basic plumage, DCB = definitive-cycle basic plumage (Wolfe et al. 2010, Johnson et al. 2011).

^f These birds are most likely birds in their definitive cycle (ASY or ATY, depending on date) with retained basic outer primaries, which requires 1 atypical molt. However, these birds conceivably could be birds in their second cycle (SY or TY, depending on date) with retained formative outer primaries, but that would require two consecutive atypical molts (see Discussion).

^g Female MAS0400 is shown in figure 4 in Braun and Schroeder (2015).

^h Female A82/1099 was opportunistically photographed and therefore was excluded from occurrence calculations in Table 2.

Table A2. Literature reviewed for evidence of atypical primary molt in greater sage-grouse.

<u>Source</u>
Beck et al. 1975
Bent 1932
Braun and Schroeder 2015
Braun et al. 2020
Brooks 1930
Connelly et al. 2003
Crunden 1963
Dalke et al. 1963
Dwight 1900
Eng 1955
Gill 1967
Girard 1937
Howell 2010
Johnsgard 2008
Johnsgard 2017
Lyons et al. 2020
Ottomeier and Crawford 1996
Patterson 1952
Petrides 1942
Petrides 1945
Schroeder and Robb 2005
Schroeder et al. 2020
Short 1967
Pyle 2007
Pyle 2008
Wright and Hiatt 1943
Young et al. 2020

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