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Memo to: Mike Armstrong, Andrew King and Robin Niver

From: Mark Ford *Mark*

Subject: Echolocation Identification Software Results – Phase III

Testing of the different sensitivity settings in Kaleidoscope Version 3.0.0 was done per the request of the developer following the same protocols as testing in fall of 2014 and earlier this year. We also reanalyzed these settings by alternatively removing Indiana bats and northern long-eared bats as a follow-up test on classification error and the propensity for false positive and false negative values. **Overall, Kaleidoscope 3.0.0 is not an improvement over earlier versions.** Based on U.S. Fish and Wildlife standards set forth for testing on the simulated New York dataset, neutral setting 0 and more accurate setting 1 failed for northern long-eared bats (*Myotis septentrionalis*) and setting 1 failed for Indiana bats (*Myotis sodalis*; Table 1). For the simulated West Virginia dataset, more accurate setting 1 failed for Indiana bats (Table 8). More sensitive setting -1, however, passed in the full community datasets for both species. When northern long-eared bats and Indiana bats were removed from the datasets, overall rates of both false positives and false negatives increased from Version 2.2.2. Software errors did not seem to be consistent between simulated datasets despite echolocation pulses being drawn from similar sources (but not duplicated among state simulations). For comparison, relevant portions of the Version 2.2.2 output are provided throughout.

cc: A. Silvis

Table 1. Post-identification per species confidence (p) from maximum likelihood estimator or surrogate (see program specifications for details) and total bat pass count for known echolocation pulses for Kaleidoscope 2.2.2 and 3.0.0 on neutral setting (0), more accurate setting (+1) and more sensitive setting (-1) for simulated New York dataset based on Ford et al. (2011). ND is total absence of probability of detection. Note: programs may identify echolocation pulses to a species without high confidence (> 0.1-0).

2.2.2	Kaleidoscope 0			Kaleidoscope +1			Kaleidoscope -1		
	ID	p	N	ID	p	N	ID	p	N
	EPFU	0.002787	14	EPFU	0.000112	11	EPFU	0.066845	15
	LABO	0	26	LABO	0	26	LABO	0	26
	LACI	0	24	LACI	0	18	LACI	0	24
	LANO	0.000016	23	LANO	0.0000001	21	LANO	0.000011	23
	MYLE	0.007305	6	MYLE	0.016342	3	MYLE	0.037367	7
	MYLU	0	57	MYLU	0	20	MYLU	0	67
	MYSE	0.000987	9	MYSE	ND	0	MYSE	0.001060	10
	MYSO	0	29	MYSO	0	11	MYSO	0	52
	PESU	0.000024	11	PESU	0.001146	6	PESU	0.001072	11
	UNKN		40	UNKN		123	UNKN		4
3.0.0									
	ID	p	N	ID	p	N	ID	p	N
	EPFU	0	30	EPFU	0	27	EPFU	0	30
	LABO	0	43	LABO	0	43	LABO	0	45
	LACI	0	20	LACI	0	20	LACI	0	20
	LANO	1	7	LANO	0	4	LANO	1	8
	MYLE	0.104946	7	MYLE	ND	ND	MYLE	0.128742	7
	MYLU	0	70	MYLU	0	70	MYLU	0	73
	MYSE	0.357554	8	MYSE	0.181958	8	MYSE	0.093352	12
	MYSO	0	33	MYSO	ND	ND	MYSO	0	35
	PESU	0.159517	8	PESU	0.212185	7	PESU	0.170268	8
	UNKN		14	UNKN		62	UNKN	2	2

Table 2. Per species echolocation pulse assignment and overall correct classification rate for Kaleidoscope 2.2.2 and 3.0.0 on neutral setting (0) for simulated New York dataset based on Ford et al. (2011). Columns in bold are known echolocation pulse assignments. Rows in italics are Kaleidoscope assignment.

2.2.2	EPFU	LABO	LACI	LANO	MYLE	MYLU	MYSE	MYSO	PESU	MISC/ODD
<i>EPFU</i>	14	0	0	0	0	0	0	0	0	0
<i>LABO</i>	0	18	0	0	0	6	0	0	1	1
<i>LACI</i>	2	0	22	0	0	0	0	0	0	0
<i>LANO</i>	10	2	0	10	0	1	0	0	0	0
<i>MYLE</i>	0	0	0	0	6	0	0	0	0	0
<i>MYLU</i>	0	0	0	0	0	51	0	4	0	2
<i>MYSE</i>	0	0	0	0	2	0	7	0	0	0
<i>MYSO</i>	0	0	0	0	0	13	2	14	0	0
<i>PESU</i>	0	1	0	0	0	1	0	0	9	0
<i>UNKN</i>	0	1	0	0	2	19	8	9	0	1
% correct	77.04									
3.0.0										
<i>EPFU</i>	24	0	2	4	0	0	0	0	0	0
<i>LABO</i>	0	22	0	0	1	16	0	1	2	1
<i>LACI</i>	0	0	20	0	0	0	0	0	0	0
<i>LANO</i>	2	0	0	5	0	0	0	0	0	0
<i>MYLE</i>	0	0	0	0	5	0	0	2	0	0
<i>MYLU</i>	0	0	0	0	0	59	1	7	0	3
<i>MYSE</i>	0	0	0	0	1	0	7	0	0	0
<i>MYSO</i>	0	0	0	0	0	14	2	17	0	0
<i>PESU</i>	0	0	0	0	0	0	0	0	8	0
<i>UNKN</i>	0	0	0	1	3	2	7	0	0	1
% correct	75.23									

Table 3. Per species echolocation pulse assignment and overall correct classification rate for Kaleidoscope 2.2.2 and 3.0.0 on more accurate setting (+1) for simulated New York dataset based on Ford et al. (2011). Columns in bold are known echolocation pulse assignments. Rows in italics are Kaleidoscope assignment.

2.2.2	EPFU	LABO	LACI	LANO	MYLE	MYLU	MYSE	MYSO	PESU	MISC/ODD
<i>EPFU</i>	11	0	0	0	0	0	0	0	0	0
<i>LABO</i>	0	18	0	0	0	6	0	0	1	1
<i>LACI</i>	0	0	18	0	0	0	0	0	0	0
<i>LANO</i>	10	0	0	10	0	1	0	0	0	0
<i>MYLE</i>	0	0	0	0	3	0	0	0	0	0
<i>MYLU</i>	0	0	0	0	0	18	0	0	0	2
<i>MYSE</i>	0	0	0	0	0	0	0	0	0	0
<i>MYSO</i>	0	0	0	0	0	5	0	6	0	0
<i>PESU</i>	0	0	0	0	0	0	0	0	6	0
<i>UNKN</i>	5	4	4	0	7	61	17	21	3	1
% correct	79.65									
3.0.0										
<i>EPFU</i>	22	0	0	4	0	0	0	0	0	0
<i>LABO</i>	0	22	0	0	1	16	0	1	2	1
<i>LACI</i>	0	0	20	0	0	0	0	0	0	0
<i>LANO</i>	0	0	0	4	0	0	0	0	0	0
<i>MYLE</i>	0	0	0	0	0	0	0	0	0	0
<i>MYLU</i>	0	0	0	0	0	59	1	7	0	3
<i>MYSE</i>	0	0	0	0	1	0	7	0	0	0
<i>MYSO</i>	0	0	0	0	0	0	0	0	0	0
<i>PESU</i>	0	0	0	0	0	0	0	0	7	0
<i>UNKN</i>	4	0	2	2	8	16	9	19	1	1
% correct	81.03									

Table 4. Per species echolocation pulse assignment and overall correct classification rate for Kaleidoscope 2.2.2 and 3.0.0 on more sensitive setting (-1) for simulated New York dataset based on Ford et al. (2011). Columns in bold are known echolocation pulse assignments. Rows in italics are Kaleidoscope assignment.

2.2.2	EPFU	LABO	LACI	LANO	MYLE	MYLU	MYSE	MYSO	PESU	MISC/ODD
<i>EPFU</i>	14	1	0	0	0	0	0	0	0	0
<i>LABO</i>	0	18	0	0	0	6	0	0	1	1
<i>LACI</i>	2	0	22	0	0	0	0	0	0	0
<i>LANO</i>	10	2	0	10	0	1	0	0	0	0
<i>MYLE</i>	0	0	0	0	6	0	0	1	0	0
<i>MYLU</i>	0	0	0	0	0	60	0	5	0	2
<i>MYSE</i>	0	0	0	0	2	0	8	0	0	0
<i>MYSO</i>	0	0	0	0	1	20	9	21	0	1
<i>PESU</i>	0	1	0	0	0	1	0	0	9	0
<i>UNKN</i>	0	0	0	0	1	3	0	0	0	0
% correct	72.73									
3.0.0										
<i>EPFU</i>	24	0	2	4	0	0	0	0	0	0
<i>LABO</i>	0	22	0	0	3	16	0	1	2	1
<i>LACI</i>	0	0	20	0	0	0	0	0	0	0
<i>LANO</i>	2	0	0	6	0	0	0	0	0	0
<i>MYLE</i>	0	0	0	0	5	0	0	2	0	0
<i>MYLU</i>	0	0	0	0	1	59	3	7	0	3
<i>MYSE</i>	0	0	0	0	1	0	11	0	0	0
<i>MYSO</i>	0	0	0	0	0	16	2	17	0	0
<i>PESU</i>	0	0	0	0	0	0	0	0	8	0
<i>UNKN</i>	0	0	0	0	0	0	1	0	0	1
% correct	73.50									

Table 5. Per species echolocation pulse assignment performance for Kaleidoscope 3.0.0 on neutral setting (0) for simulated New York dataset based on Ford et al. (2011). Threshold is the proportional abundance of per species echolocation pulses. AUC is area under the curve. Omission is proportion of occurrences misidentified adjusted by the threshold value. Sensitivity is the proportion of true events assigned correctly (assessment of true positive). Specificity is the proportion of non-events assigned correctly (assessment of true negative). Kappa measures the proportion of correct classification after accounting for the probability of chance agreement.

	Threshold	AUC	Omission	Sensitivity	Specificity	Kappa
EPFU	0.11	0.95	0.08	0.92	0.97	0.84
LABO	0.09	0.95	0.00	1.00	0.90	0.63
LACI	0.09	0.95	0.09	0.91	1.00	0.95
LANO	0.04	0.75	0.50	0.50	0.99	0.57
MYLE	0.04	0.75	0.50	0.50	0.99	0.57
MYLU	0.38	0.79	0.35	0.65	0.93	0.60
MYSE	0.07	0.70	0.59	0.41	1.00	0.54
MYSO	0.11	0.78	0.37	0.63	0.92	0.51
PESU	0.04	0.90	0.20	0.80	1.00	0.88

Table 6. Per species echolocation pulse assignment performance for Kaleidoscope 3.0.0 on more accurate setting (+1) for simulated New York dataset based on Ford et al. (2011). Threshold is the proportional abundance of per species echolocation pulses. AUC is area under the curve. Omission is proportion of occurrences misidentified adjusted by the threshold value. Sensitivity is the proportion of true events assigned correctly (assessment of true positive). Specificity is the proportion of non-events assigned correctly (assessment of true negative). Kappa measures the proportion of correct classification after accounting for the probability of chance agreement.

	Threshold	AUC	Omission	Sensitivity	Specificity	Kappa
EPFU	0.11	0.91	0.15	0.85	0.98	0.83
LABO	0.09	0.95	0.00	1.00	0.90	0.63
LACI	0.09	0.95	0.09	0.91	1.00	0.95
LANO	0.04	0.70	0.60	0.40	1.00	0.56
MYLE	ND	ND	ND	ND	ND	ND
MYLU	0.38	0.79	0.35	0.65	0.93	0.60
MYSE	0.07	0.70	0.59	0.41	1.00	0.54
MYSO	0.04	0.85	0.30	0.70	1.00	0.82
PESU	0.11	0.91	0.15	0.85	0.98	0.83

Table 7. Per species echolocation pulse assignment performance for Kaleidoscope 3.0.0 on more sensitive setting (-1) for simulated New York dataset based on Ford et al. (2011). Threshold is the proportional abundance of per species echolocation pulses. AUC is area under the curve. Omission is proportion of occurrences misidentified adjusted by the threshold value. Sensitivity is the proportion of true events assigned correctly (assessment of true positive). Specificity is the proportion of non-events assigned correctly (assessment of true negative). Kappa measures the proportion of correct classification after accounting for the probability of chance agreement.

	Threshold	AUC	Omission	Sensitivity	Specificity	Kappa
EPFU	0.11	0.95	0.08	0.92	0.97	0.84
LABO	0.09	0.95	0.00	1.00	0.89	0.61
LACI	0.09	0.95	0.09	0.91	1.00	0.95
LANO	0.04	0.80	0.40	0.60	0.99	0.65
MYLE	0.04	0.75	0.50	0.50	0.99	0.57
MYLU	0.38	0.78	0.35	0.65	0.91	0.58
MYSE	0.07	0.82	0.35	0.65	1.00	0.74
MYSO	0.11	0.77	0.37	0.63	0.92	0.48
PESU	0.04	0.90	0.20	0.80	1.00	0.88

Table 8. Post-identification per species confidence from maximum likelihood estimator or surrogate (see program specifications for details) for known echolocation pulses for Kaleidoscope 2.2.2 and 3.0.0 on neutral setting (0), more accurate setting (+1) and more sensitive setting (-1) West Virginia dataset based on Ford et al. (2005). ND is total absence of probability of detection. Note: programs may identify echolocation pulses to a species without high confidence ($> 0.1-0$).

2.2.2	Kaleidoscope 0			Kaleidoscope +1			Kaleidoscope -1		
	ID	p	N	ID	p	N	ID	p	N
	EPFU	0.000343	15	EPFU	0.000108	11	EPFU	0.001612	18
	LABO	0	37	LABO	0	37	LABO	0	37
	LACI	0	25	LACI	0	19	LACI	0	25
	LANO	0.004615	18	LANO	0.000187	16	LANO	0.004052	18
	MYLE	1	1	MYLE	ND	0	MYLE	0.917026	3
	MYLU	0	36	MYLU	0.000002	18	MYLU	0.000001	44
	MYSE	0	14	MYSE	0.215773	3	MYSE	0	15
	MYSO	0	38	MYSO	0	16	MYSO	0	52
	PESU	0	18	PESU	0	16	PESU	0.000001	18
	UNKN		31	UNKN		97	UNKN		3

3.0.0	ID	p	N	ID	p	N	ID	p	
		EPFU	0	28	EPFU	0	24	EPFU	0
	LABO	0	52	LABO	0	52	LABO	0	52
	LACI	0	21	LACI	0	21	LACI	0	21
	LANO	1	5	LANO	1	2	LANO	1	5
	MYLE	0.514934	5	MYLE	ND	ND	MYLE	0.518885	5
	MYLU	0	55	MYLU	0	55	MYLU	0	55
	MYSE	0.000808	14	MYSE	0.004871	11	MYSE	0.000843	16
	MYSO	0	35	MYSO	1	2	MYSO	0	35
	PESU	0.00029	15	PESU	0.000349	14	PESU	0.000209	15
	UNKN		3	UNKN		52	UNKN		1

Table 12. Per species echolocation pulse assignment performance for Kaleidoscope 3.0.0 on neutral setting (0) for simulated West Virginia dataset based on Ford et al. (2005). Threshold is the proportional abundance of per species echolocation pulses. AUC is area under the curve. Omission is proportion of occurrences misidentified adjusted by the threshold value. Sensitivity is the proportion of true events assigned correctly (assessment of true positive). Specificity is the proportion of non-events assigned correctly (assessment of true negative). Kappa measures the proportion of correct classification after accounting for the probability of chance agreement.

	Threshold	AUC	Omission	Sensitivity	Specificity	Kappa
EPFU	0.11	0.95	0.08	0.92	0.98	0.87
LABO	0.17	0.95	0.03	0.98	0.93	0.81
LACI	0.09	0.95	0.09	0.91	1.00	0.92
LANO	0.02	0.80	0.40	0.60	0.99	0.59
MYLE	0.04	0.55	0.89	0.11	0.98	0.12
MYLU	0.26	0.76	0.38	0.62	0.90	0.53
MYSE	0.10	0.78	0.43	0.57	1.00	0.68
MYSO	0.12	0.81	0.30	0.70	0.92	0.55
PESU	0.06	0.89	0.20	0.80	0.99	0.79

Table 13. Per species echolocation pulse assignment performance for Kaleidoscope 3.0.0 on more accurate setting (+1) for simulated West Virginia dataset based on Ford et al. (2005). Threshold is the proportional abundance of per species echolocation pulses. AUC is area under the curve. Omission is proportion of occurrences misidentified adjusted by the threshold value. Sensitivity is the proportion of true events assigned correctly (assessment of true positive). Specificity is the proportion of non-events assigned correctly (assessment of true negative). Kappa measures the proportion of correct classification after accounting for the probability of chance agreement.

	Threshold	AUC	Omission	Sensitivity	Specificity	Kappa
EPFU	0.11	0.92	0.15	0.85	0.99	0.87
LABO	0.17	0.95	0.03	0.98	0.93	0.81
LACI	0.09	0.95	0.09	0.91	1.00	0.92
LANO	0.02	0.70	0.60	0.40	1.00	0.57
MYLE	ND	ND	ND	ND	ND	ND
MYLU	0.26	0.76	0.38	0.62	0.90	0.53
MYSE	0.10	0.72	0.57	0.43	1.00	0.56
MYSO	0.12	0.54	0.93	0.07	1.00	0.12
PESU	0.06	0.90	0.20	0.80	0.99	0.82

Table 14. Per species echolocation pulse assignment performance for Kaleidoscope 3.0.0 on more sensitive setting (-1) for simulated West Virginia dataset based on Ford et al. (2005). Threshold is the proportional abundance of per species echolocation pulses. AUC is area under the curve. Omission is proportion of occurrences misidentified adjusted by the threshold value. Sensitivity is the proportion of true events assigned correctly (assessment of true positive). Specificity is the proportion of non-events assigned correctly (assessment of true negative). Kappa measures the proportion of correct classification after accounting for the probability of chance agreement.

	Threshold	AUC	Omission	Sensitivity	Specificity	Kappa
EPFU	0.11	0.95	0.08	0.92	0.98	0.87
LABO	0.17	0.95	0.03	0.98	0.93	0.81
LACI	0.09	0.95	0.09	0.91	1.00	0.92
LANO	0.02	0.80	0.40	0.60	0.99	0.59
MYLE	0.04	0.55	0.89	0.11	0.98	0.12
MYLU	0.26	0.76	0.38	0.62	0.90	0.53
MYSE	0.10	0.82	0.35	0.65	1.00	0.75
MYSO	0.12	0.81	0.30	0.70	0.92	0.55
PESU	0.06	0.89	0.20	0.80	0.99	0.79

Table 15. Post-identification per species confidence from maximum likelihood estimator or surrogate for known echolocation pulses for Kaleidoscope 2.2.2 on neutral setting (0), more accurate setting (+1) and more sensitive setting (-1) for simulated New York and West Virginia datasets based on Ford et al. (2011, 2005) with Northern long-eared bat (*Myotis septentrionalis*; MYSE) and/or Indiana bat (*Myotis sodalis*; MYSO) alternatively removed or retained. High confidence of predicted presence indicated at $p < 0.1$. ND is total absence of probability of detection. False positives (bold), false negatives (italics) noted.

			Kaleidoscope 0	Kaleidoscope +1	Kaleidoscope -1
New York	No MYSE	MYSE presence	1	ND	0.99568
New York	No MYSE	MYSO presence	0	0	0
New York	No MYSO	MYSE presence	0.00039	<i>ND</i>	0.0003
New York	No MYSO	MYSO presence	0.00002	0.00382	0
West Virginia	No MYSE	MYSE presence	0.60729	0.96070	0.61934
West Virginia	No MYSE	MYSO presence	0	0	0
West Virginia	No MYSO	MYSE presence	0	<i>0.21060</i>	0
West Virginia	No MYSO	MYSO presence	0	0.00022	0

Table 16. Post-identification per species confidence from maximum likelihood estimator or surrogate for known echolocation pulses for Kaleidoscope 3.0.0 on neutral setting (0), more accurate setting (+1) and more sensitive setting (-1) for simulated New York and West Virginia datasets based on Ford et al. (2011, 2005) with Northern long-eared bat (*Myotis septentrionalis*; MYSE) and/or Indiana bat (*Myotis sodalis*; MYSO) alternatively removed or retained. High confidence of predicted presence indicated at $p < 0.1$. ND is total absence of probability of detection. False positives (bold), false negatives (italics) noted.

			Kaleidoscope 0	Kaleidoscope +1	Kaleidoscope -1
New York	No MYSE	MYSE presence	1	1	1
New York	No MYSE	MYSO presence	0	<i>ND</i>	0
New York	No MYSO	MYSE presence	<i>0.240137</i>	<i>0.12788</i>	0.030439
New York	No MYSO	MYSO presence	0.000449	ND	0.000705
West Virginia	No MYSE	MYSE presence	1	1	1
West Virginia	No MYSE	MYSO presence	0	<i>1</i>	0
West Virginia	No MYSO	MYSE presence	0.00271	0.002931	0.000104
West Virginia	No MYSO	MYSO presence	0.00863	ND	0.000814