
Figure 7.1 Counting accumulative spikes of ARC neurones using mathematical approach

- A:** A representative ARC neurone whole-cell patch-clamp recording indicating the area in which neurone spikes should be counted (green bar) and should not be counted (red bar) due to a negative current injection. For counting spikes, two different functions are used in MATLAB; counting without (solid blue bar, at the start of experiment before meeting the first negative current pulse where the indicative value, lower threshold, is stated) and with time loop function (dashed blue bar, starts from the first negative current injection and repeats every five seconds to ensure that in each five seconds, the spikes which are induced by negative current injection are ignored).
- Bi:** A sample of a continuous whole-cell current-clamp recording from an ARC neurone with a resting membrane potential of -46.0 mV at start. The regular negative current injections (5-20 pA, 1.0 s, 0.2 Hz). The trace shows a response of neurone to increased extracellular glucose concentration (from 0.2 to 0.5 mM).
- Bii:** A sample of cumulative firing frequency plot of recorded neurone in Bi (black) overlaid with the model fitting (red) by estimated parameters from equation (7.1).

Figure 7.2 Comparison of activity at the end of each extracellular glucose concentration application, λ_2 , of neurones in inhibition without reversal group (GE w/o R neurone) in both *ad libitum* fed and 24-hour fasted rats

- A:** The graphical representation of activity at the end of each extracellular glucose concentration application, λ_2 , of individual recorded neurone in inhibition without reversal group in both *ad libitum* fed and 24-hour fasted rats as indicated. A total of 5 neurones were recorded from *ad libitum* fed rats and one neurone was recorded from 24-hour fasted rats.
- B:** Bar-chart comparing the average neurone activity at the end of each extracellular glucose concentration application, λ_2 , of neurones in inhibition without reversal group obtained in (A) both *ad libitum* fed (black) and 24-hour fasted rats (dense-light grey).

Figure 7.3 Comparison of time, T , and duration of the transition, τ , of neurones in inhibition without reversal group (GE w/o R neurone) in both *ad libitum* fed and 24-hour fasted rats

- A:** Bar-chart comparing the average half sigmoid time (T) at each glucose application of neurone in inhibition without reversal group (GE w/o R neurone) recorded in both *ad libitum* fed (black) and 24-hour fasted rats (dense-light grey).
- B:** Bar-chart comparing the average duration of the transition (τ) at each glucose application of neurone in inhibition without reversal group (GE w/o R neurone) recorded in both *ad libitum* fed (black) and 24-hour fasted rats (dense-light grey).

Figure 7.4 Comparison of dynamic behaviour of neurones in inhibition without reversal (GE w/o R neurone) group recorded from *ad libitum* fed rats in all step changes in extracellular glucose concentration (2.0 - 0.2 – 0.5 – 1.0 – 2.0 – 5.0 mM)

The graphical representation showing individual neurone activity (spikes/second) with continuous time of inhibition without reversal group (GE w/o R neurone) in a change in glucose concentration from (A) 2.0 to 0.2 mM, (B) 0.2 to 0.5 mM, (C) 0.5 to 1.0 mM, (D) 1.0 to 2.0 mM and (E) 2.0 to 5.0 mM. A total of 5, 5, 5, 5 and 4 neurones from *ad libitum* fed rats were investigated in (A), (B), (C), (D) and (E), respectively. Note in (E) that another neurone was omitted since it had a bad recording. Each colour represents individual neurone. X-axis represents time in seconds and Y-axis represents spikes/second.

Figure 7.5 Comparison of dynamic behaviour of neurones in inhibition without reversal (GE w/o R neurone) group recorded from 24-hour fasted rats in a change in extracellular glucose concentration from 2.0 to 0.2 mM

The graphical representation showing individual neurone activity (spikes/second) with continuous time of inhibition without reversal group (GE w/o R neurone) in a change in glucose concentration from 2.0 to 0.2 mM. Only 1 neurone from 24-hour fasted rat was investigated. Black line represents the activity of this neurone. Given that the recording of this neurone was not good for the rest of experiments, an investigation of this neurone activity was only performed in this glucose application. X-axis represents time in seconds and Y-axis represents spikes/second.

Figure 7.6 Comparison of activity at the end of each extracellular glucose concentration application, λ_2 , of neurones in inhibition with reversal group (GE w/R neurone) in both *ad libitum* fed and 24-hour fasted rats

- A:** The graphical representation of activity at the end of each extracellular glucose concentration application, λ_2 , of individual recorded neurone in inhibition with reversal group in *ad libitum* fed rats as indicated. A total of 4 neurones recorded from *ad libitum* fed rats were investigated.
- B:** The graphical representation of activity at the end of each extracellular glucose concentration application, λ_2 , of individual recorded neurone in inhibition with reversal group in 24-hour fasted rats as indicated. A total of 8 neurones recorded from 24-hour fasted rats were investigated.
- C:** Bar-chart comparing the average neurone activity at the end of each extracellular glucose concentration application, λ_2 , of neurones in inhibition with reversal group obtained in (A and B) both *ad libitum* fed (black) and 24-hour fasted rats (dense-light grey).

Figure 7.7 Comparison of time, T , and duration of the transition, τ , of neurones in inhibition with reversal group (GE w/R neurone) in both *ad libitum* fed and 24-hour fasted rats

- A:** Bar-chart comparing the average half sigmoid time (T) at each glucose application of neurone in inhibition with reversal group (GE neurone) recorded in both *ad libitum* fed (black) and 24-hour fasted rats (dense-light grey). A statistically detectable significance in T between *ad libitum* fed and 24-hour fasted rats is indicated as * and ** with $P < 0.05$ and $P < 0.01$, respectively.
- B:** Bar-chart comparing the average duration of the transition (τ) at each glucose application of neurone in inhibition with reversal group (GE w/R neurone) recorded in both *ad libitum* fed (black) and 24-hour fasted rats (dense-light grey).

Figure 7.8 Comparison of dynamic behaviour of neurones in inhibition with reversal (GE w/R neurone) group recorded from *ad libitum* fed rats in all changes in extracellular glucose concentration (2.0 - 0.2 - 0.5 - 1.0 - 2.0 - 5.0 mM)

The graphical representation showing individual neurone activity (spikes/second) with continuous time of inhibition with reversal group (GE w/R neurone) in a change in glucose concentration from (A) 2.0 to 0.2 mM, (B) 0.2 to 0.5 mM, (C) 0.5 to 1.0 mM, (D) 1.0 to 2.0 mM and (E) 2.0 to 5.0 mM. A total of 4, 4, 4, 4 and 2 neurones from *ad libitum* fed rats were investigated in (A), (B), (C), (D) and (E), respectively. Note in (E) that another two neurones were omitted since they had bad recordings. Each colour represents individual neurone. X-axis represents time in seconds and Y-axis represents spikes/second.

Figure 7.9 Comparison of dynamic behaviour of neurones in inhibition with reversal (GE w/R neurone) group recorded from 24-hour fasted rats in all changes in extracellular glucose concentration (2.0 - 0.2 - 0.5 - 1.0 - 2.0 - 5.0 mM)

The graphical representation showing individual neurone activity (spikes/second) with continuous time of inhibition with reversal group (GE w/R neurone) in a change in glucose concentration from (A) 2.0 to 0.2 mM, (B) 0.2 to 0.5 mM, (C) 0.5 to 1.0 mM, (D) 1.0 to 2.0 mM and (E) 2.0 to 5.0 mM. A total of 8, 8, 7, 5 and 4 neurones from 24-hour fasted rats were investigated in (A), (B), (C), (D) and (E), respectively. Note that 1, 3 and 4 neurones in (C), (D) and (E), respectively were omitted since they had poor recordings. Each colour represents individual neurone. X-axis represents time in seconds and Y-axis represents spikes/second.

Figure 7.10 Comparison of activity at the end of each extracellular glucose concentration application, λ_2 , of neurones in excitation group (GI neurone) in both *ad libitum* fed and 24-hour fasted rats

- A:** The graphical representation of activity at the end of each extracellular glucose concentration application, λ_2 , of individual recorded neurone in excitation group in *ad libitum* fed rats as indicated. A total of 3 neurones recorded from *ad libitum* fed rats were investigated.
- B:** The graphical representation of activity at the end of each extracellular glucose concentration application, λ_2 , of individual recorded neurone in excitation group in 24-hour fasted rats as indicated. A total of 4 neurones recorded from 24-hour fasted rats were investigated.
- C:** Bar-chart comparing the average neurone activity at the end of each extracellular glucose concentration application, λ_2 , of neurones in excitation group obtained in (A and B) both *ad libitum* fed (black) and 24-hour fasted rats (dense-light grey).

Figure 7.11 Comparison of time, T , and duration of the transition, τ , of neurones in excitation group (GI neurone) in both *ad libitum* fed and 24-hour fasted rats

- A:** Bar-chart comparing the average half sigmoid time (T) at each glucose application of neurone in excitation group (GI neurone) recorded in both *ad libitum* fed (black) and 24-hour fasted rats (dense-light grey).
- B:** Bar-chart comparing the average duration of the transition (τ) at each glucose application of neurone in excitation group (GI neurone) recorded in both *ad libitum* fed (black) and 24-hour fasted rats (dense-light grey).

Figure 7.12 Comparison of dynamic behaviour of neurones in excitation (GI neurone) group recorded from *ad libitum* fed rats in all changes in extracellular glucose concentration (2.0 - 0.2 – 0.5 – 1.0 – 2.0 – 5.0 mM)

The graphical representation showing individual neurone activity (spikes/second) with continuous time of excitation group (GI neurone) in a change in glucose concentration from (A) 2.0 to 0.2 mM, (B) 0.2 to 0.5 mM, (C) 0.5 to 1.0 mM, (D) 1.0 to 2.0 mM and (E) 2.0 to 5.0 mM. A total of 3, 3, 3, 3 and 3 neurones from *ad libitum* fed rats were investigated in (A), (B), (C), (D) and (E), respectively. Each colour represents individual neurone. X-axis represents time in seconds and Y-axis represents spikes/second.

Figure 7.13 Comparison of dynamic behaviour of neurones in excitation (GI neurone) group recorded from 24-hour fasted rats in all changes in extracellular glucose concentration (2.0 - 0.2 – 0.5 – 1.0 – 2.0 – 5.0 mM)

The graphical representation showing individual neurone activity (spikes/second) with continuous time of excitation group (GI neurone) in a change in glucose concentration from (A) 2.0 to 0.2 mM, (B) 0.2 to 0.5 mM, (C) 0.5 to 1.0 mM, (D) 1.0 to 2.0 mM and (E) 2.0 to 5.0 mM. A total of 4, 4, 4, 2 and 2 neurones from 24-hour fasted rats were investigated in (A), (B), (C), (D) and (E), respectively. Note that 2 and 2 neurones in (D) and (E), respectively were omitted since one of them was dead and all spikes from another neurone were induced by negative injected current. Each colour represents individual neurone. X-axis represents time in seconds and Y-axis represents spikes/second.

Figure 7.14 Comparison of activity at the end of each extracellular glucose concentration application, λ_2 , of neurones in rapidly adapting group (GRA neurone) in *ad libitum* fed rats

- A:** The graphical representation of activity at the end of each extracellular glucose concentration application, λ_2 , of individual recorded neurone in rapidly adapting group in *ad libitum* fed rats as indicated. A total of 2 neurones recorded from *ad libitum* fed rats were investigated.
- B:** Bar-chart comparing the average neurone activity at the end of each extracellular glucose concentration application, λ_2 , of neurones in rapidly adapting group obtained in (A and B) in *ad libitum* fed rats (black).

Figure 7.15 Comparison of time, T , and duration of the transition, τ , of neurones in rapidly adapting group (GRA neurone) in *ad libitum* fed rats

- A:** Bar-chart comparing the average half sigmoid time (T) at each glucose application of neurone in rapidly adapting group (GRA neurone) recorded in *ad libitum* fed rats (black).
- B:** Bar-chart comparing the average duration of the transition (τ) at each glucose application of neurone in rapidly adapting group (GRA neurone) recorded in *ad libitum* fed rats (black).

Figure 7.16 Comparison of dynamic behaviour of neurones in rapidly adapting (GRA neurone) group recorded from *ad libitum* fed rats in all changes in extracellular glucose concentration (2.0 - 0.2 – 0.5 – 1.0 – 2.0 – 5.0 mM)

The graphical representation showing individual neurone activity (spikes/second) with continuous time of rapidly adapting group (GRA neurone) in a change in glucose concentration from (A) 2.0 to 0.2 mM, (B) 0.2 to 0.5 mM, (C) 0.5 to 1.0 mM, (D) 1.0 to 2.0 mM and (E) 2.0 to 5.0 mM. A total of 2, 2, 2, 2 and 2 neurones from *ad libitum* fed rats were investigated in (A), (B), (C), (D) and (E), respectively. Each colour represents individual neurone. X-axis represents time in seconds and Y-axis represents spikes/second.

Figure 7.17 Comparison of activity at the end of each extracellular glucose concentration application, λ_2 , of neurones in inhibition no response group (non glucose-sensing neurone) in both *ad libitum* fed and 24-hour fasted rats

- A:** The graphical representation of activity at the end of each extracellular glucose concentration application, λ_2 , of individual recorded neurone in no response group in both *ad libitum* fed and 24-hour fasted rats as indicated. A total of 1 neurone was recorded from *ad libitum* fed rats and a total of 4 neurones were recorded from 24-hour fasted rats.
- B:** Bar-chart comparing the average neurone activity at the end of each extracellular glucose concentration application, λ_2 , of neurones in no response group obtained in (A) both *ad libitum* fed (black) and 24-hour fasted rats (dense-light grey).

Figure 7.18 Comparison of time, T , and duration of the transition, τ , of neurones in no response group (non glucose-sensing neurone) in both *ad libitum* fed and 24-hour fasted rats

- A:** Bar-chart comparing the average half sigmoid time (T) at each glucose application of neurone in no response group recorded in both *ad libitum* fed (black) and 24-hour fasted rats (dense-light grey).
- B:** Bar-chart comparing the average duration of the transition (τ) at each glucose application of neurone in no response group recorded in both *ad libitum* fed (black) and 24-hour fasted rats (dense-light grey).

Figure 7.19 Comparison of dynamic behaviour of neurones in no response group (non glucose-sensing neurone) recorded from *ad libitum* fed rats in all changes in extracellular glucose concentration (2.0 - 0.2 – 0.5 – 1.0 – 2.0 – 5.0 mM)

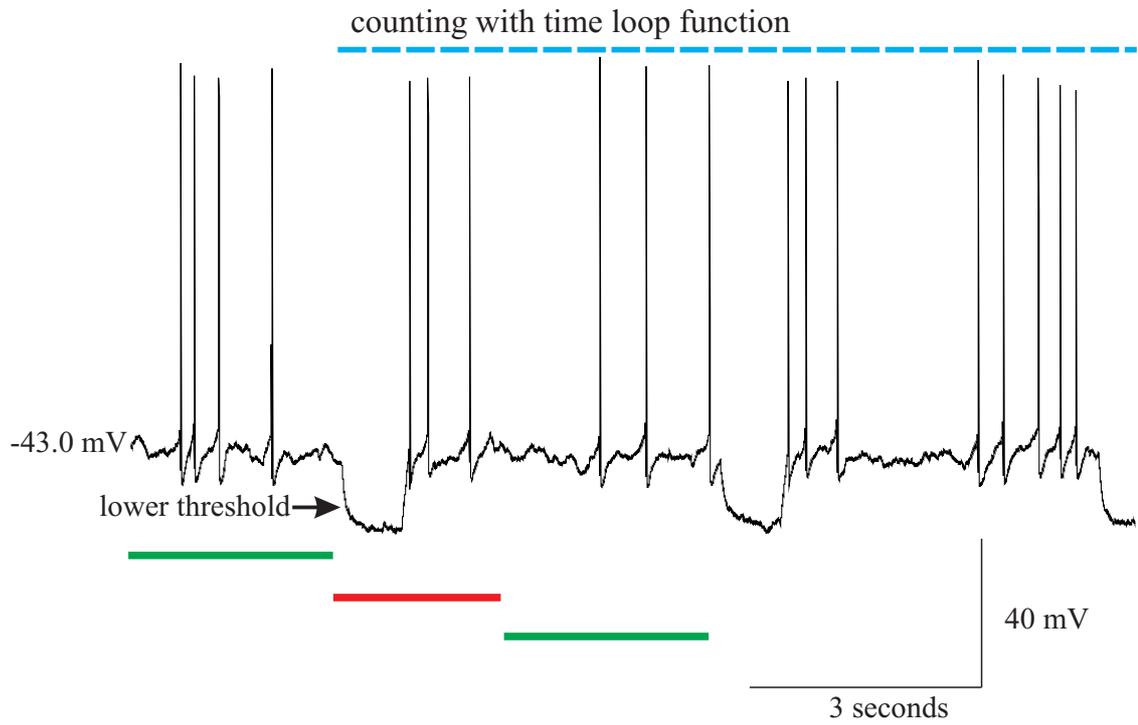
The graphical representation showing individual neurone activity (spikes/second) with continuous time of no response group (non glucose-sensing neurone) in a change in glucose concentration from (A) 2.0 to 0.2 mM, (B) 0.2 to 0.5 mM, (C) 0.5 to 1.0 mM, (D) 1.0 to 2.0 mM and (E) 2.0 to 5.0 mM. Only one neurone from *ad libitum* fed rats was investigated in (A), (B), (C), (D) and (E), respectively. Each colour represents individual neurone. X-axis represents time in seconds and Y-axis represents spikes/second.

Figure 7.20 Comparison of dynamic behaviour of neurones in no response group (non glucose-sensing neurone) recorded from 24-hour fasted rats in all changes in extracellular glucose concentration (2.0 - 0.2 – 0.5 – 1.0 – 2.0 – 5.0 mM)

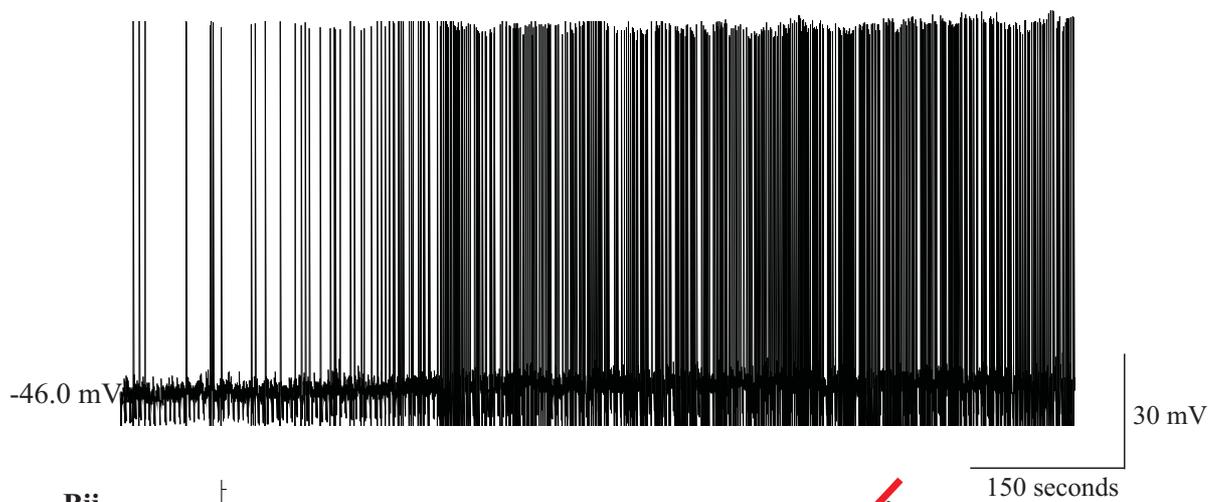
The graphical representation showing individual neurone activity (spikes/second) with continuous time of no response group (non glucose-sensing neurone) in a change in glucose concentration from (A) 2.0 to 0.2 mM, (B) 0.2 to 0.5 mM, (C) 0.5 to 1.0 mM, (D) 1.0 to 2.0 mM and (E) 2.0 to 5.0 mM. A total of 4, 4, 4, 4 and 4 neurones from 24-hour fasted rats were investigated in (A), (B), (C), (D) and (E), respectively. Each colour represents individual neurone. X-axis represents time in seconds and Y-axis represents spikes/second.

Figure 7.1

A counting without time loop function



Bi



Bii

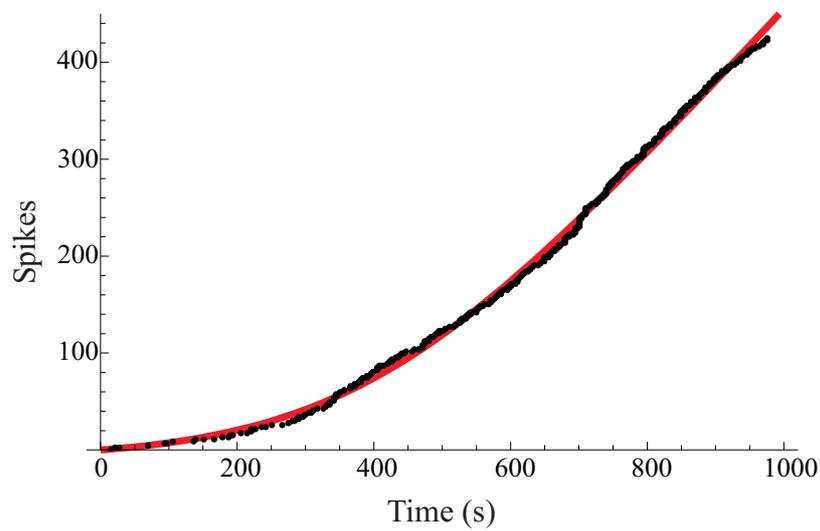


Figure 7.2

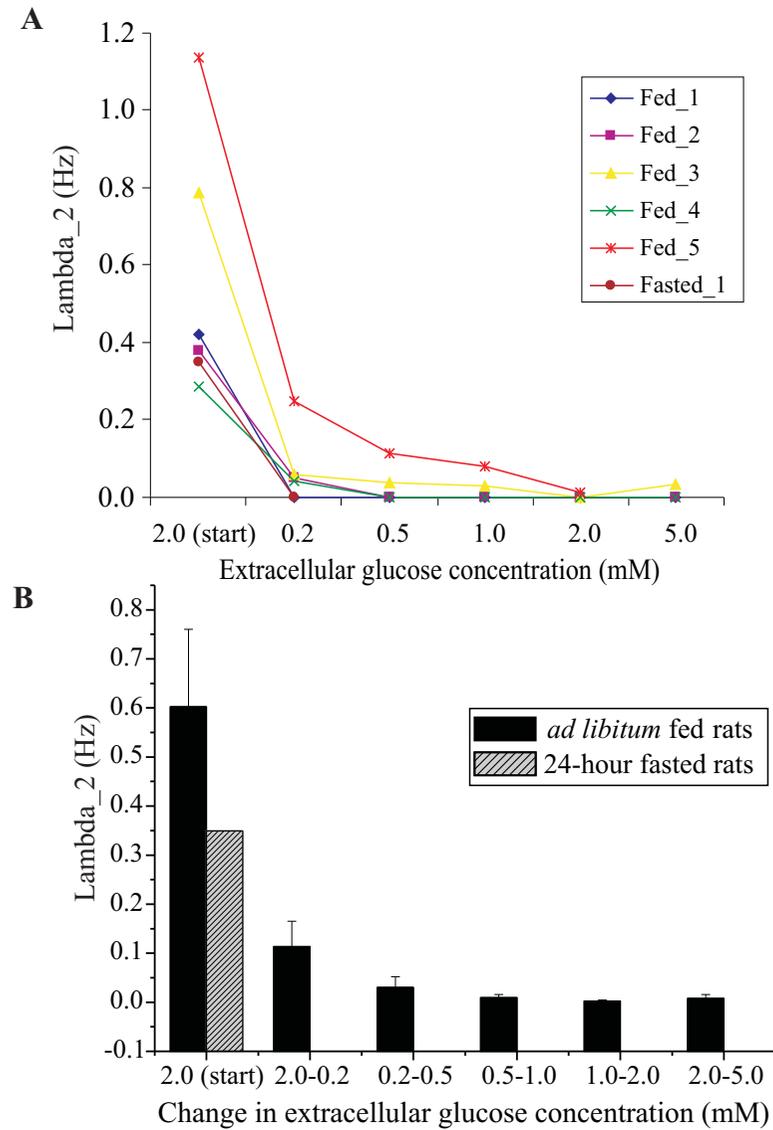


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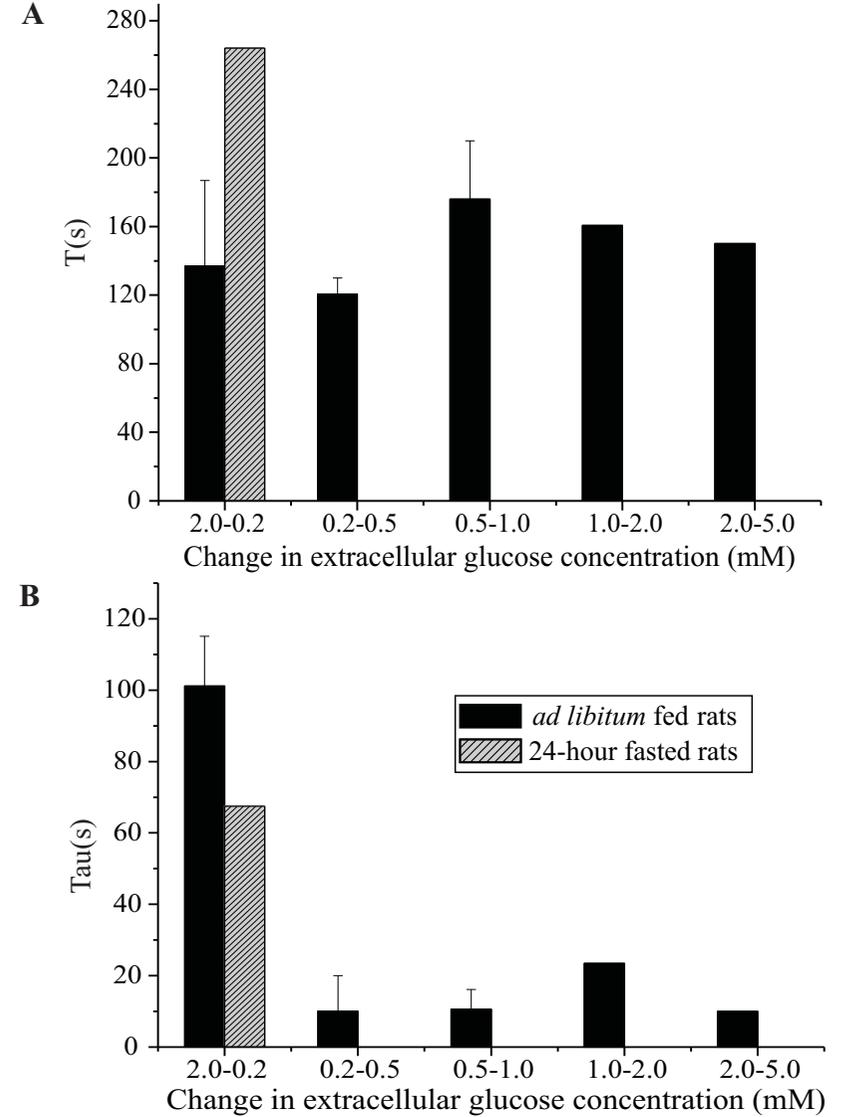


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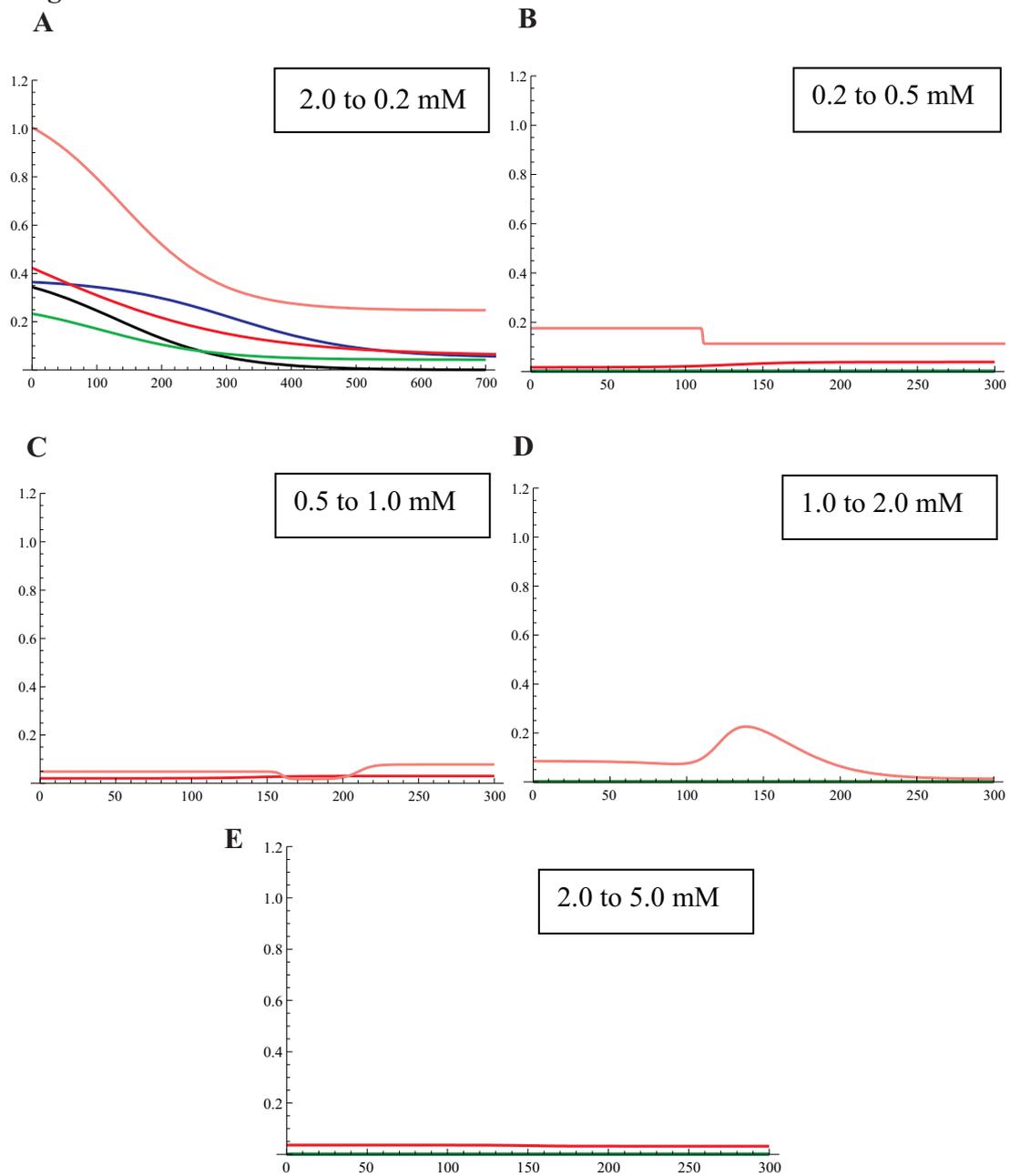


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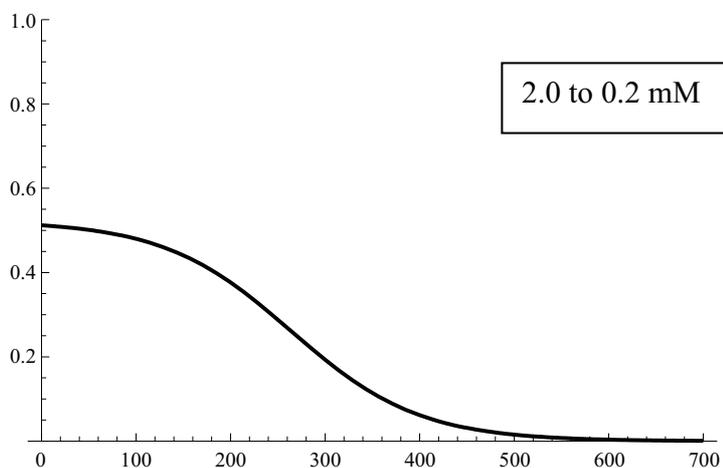


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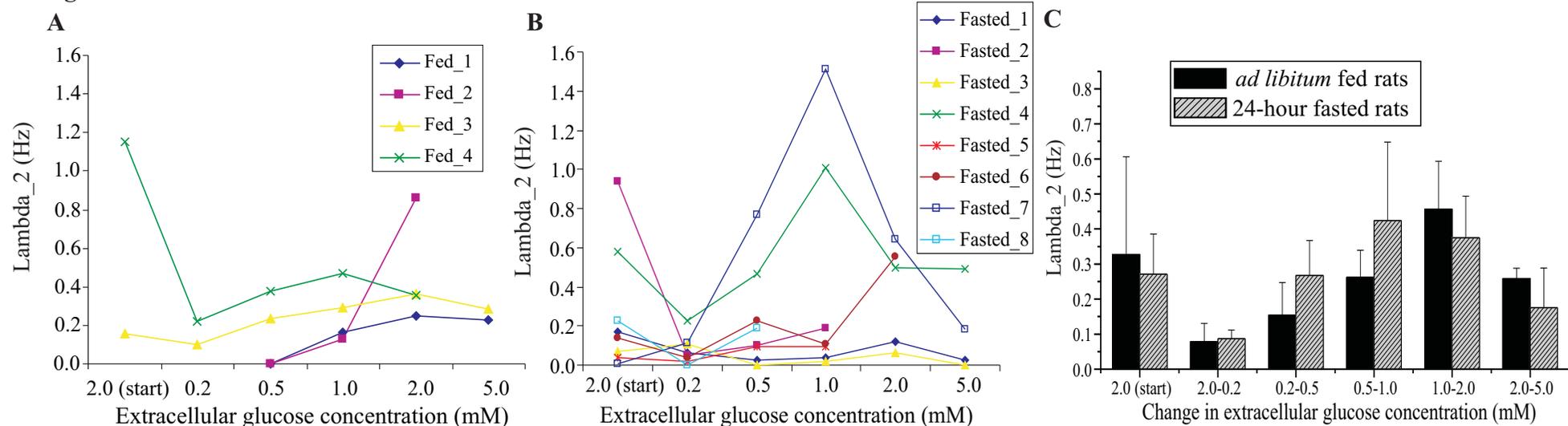


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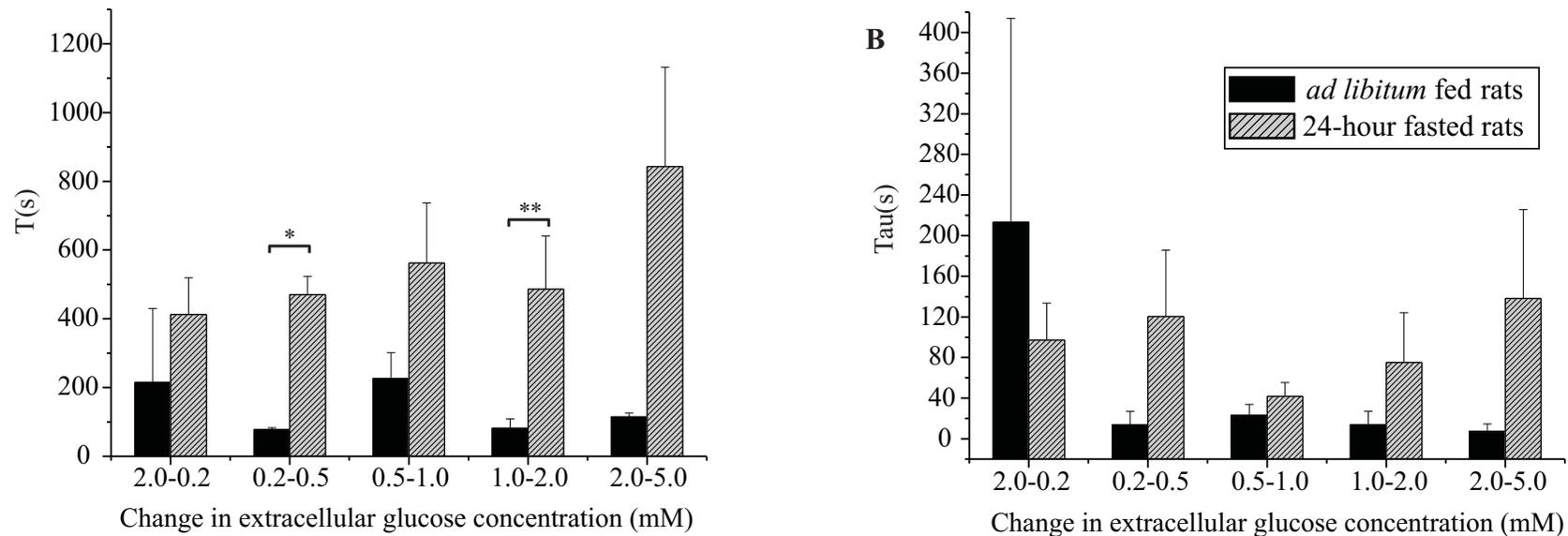


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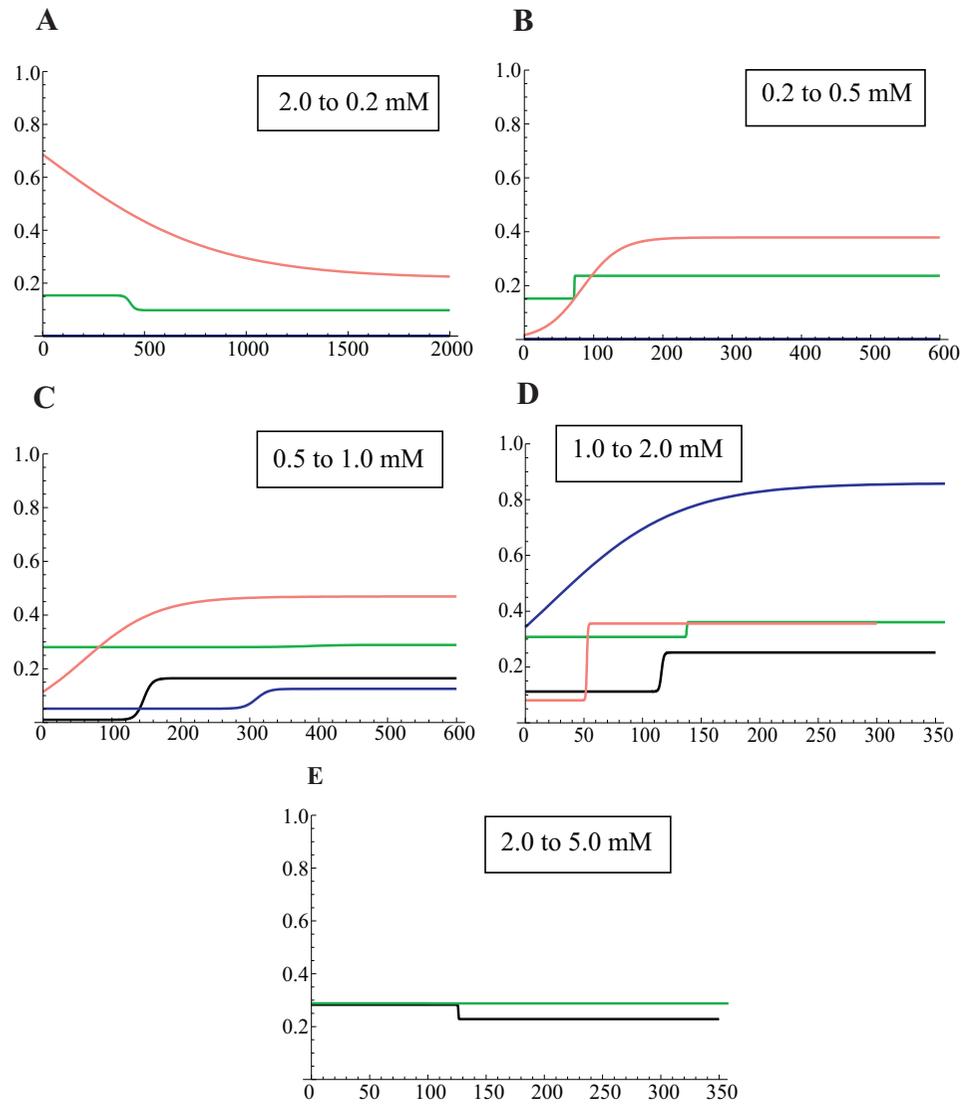


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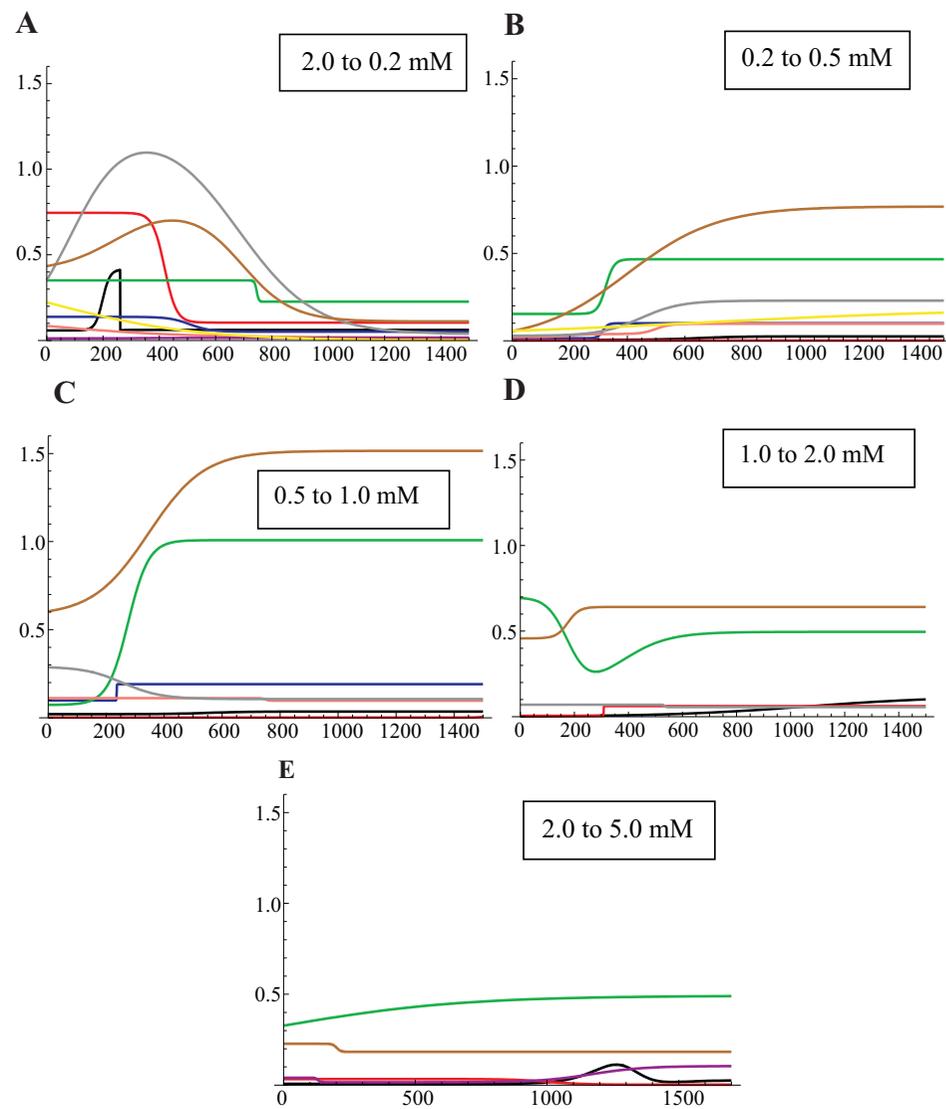


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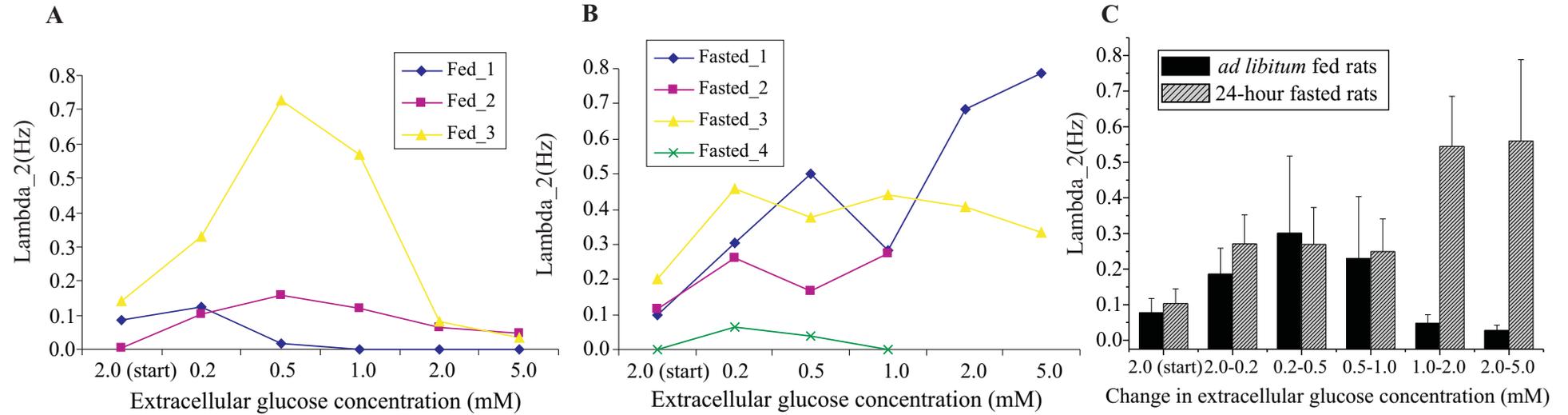


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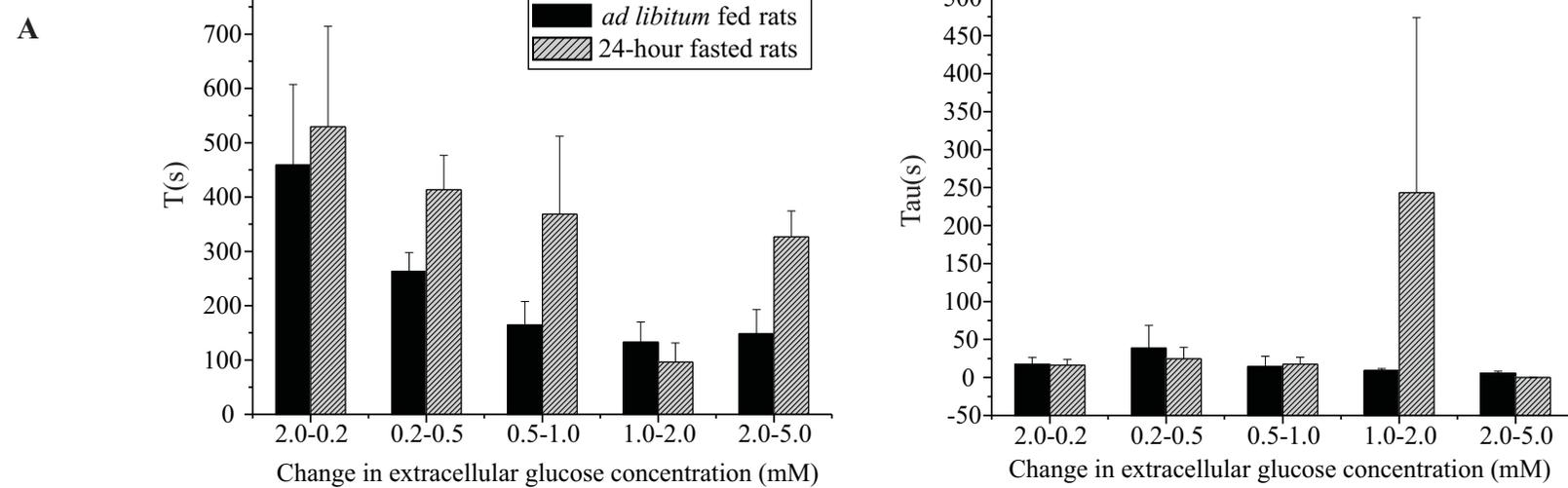


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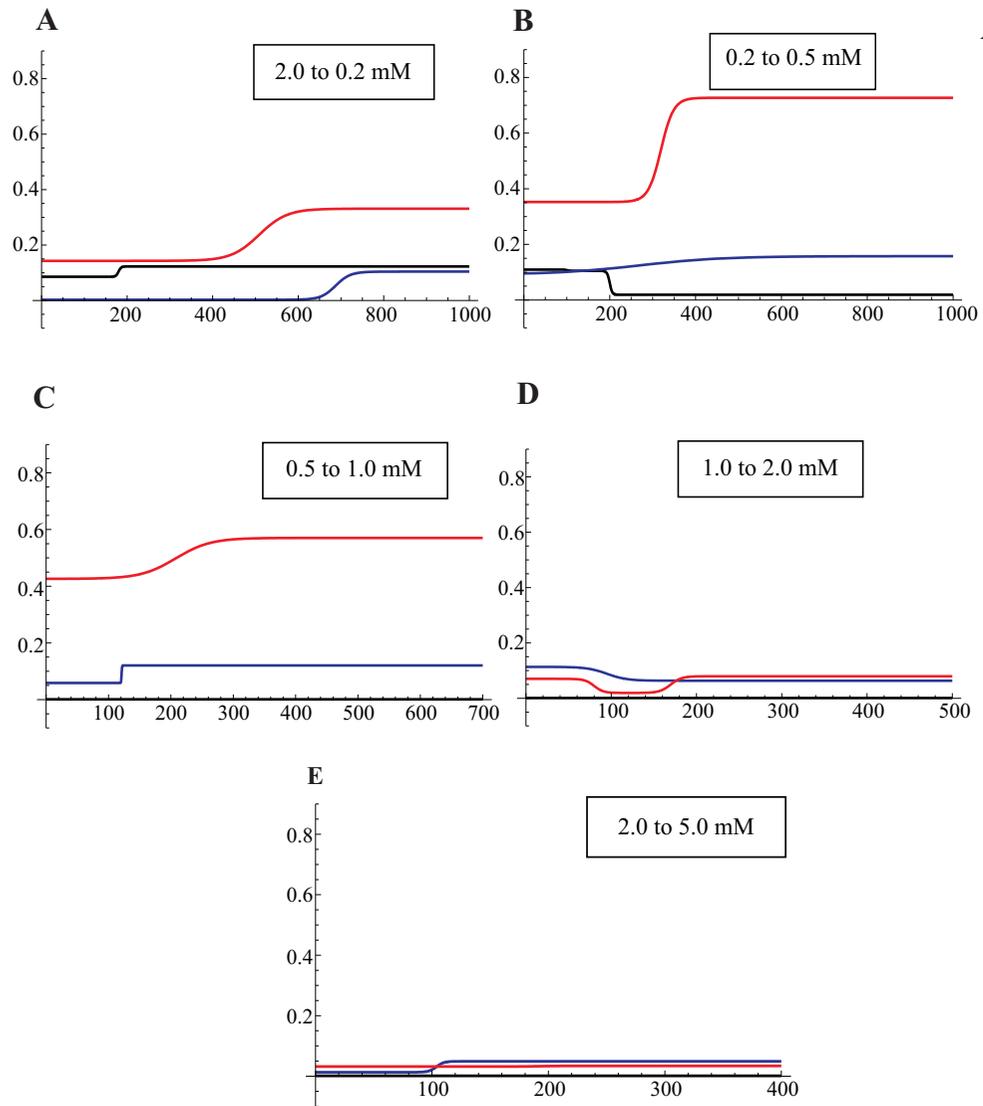


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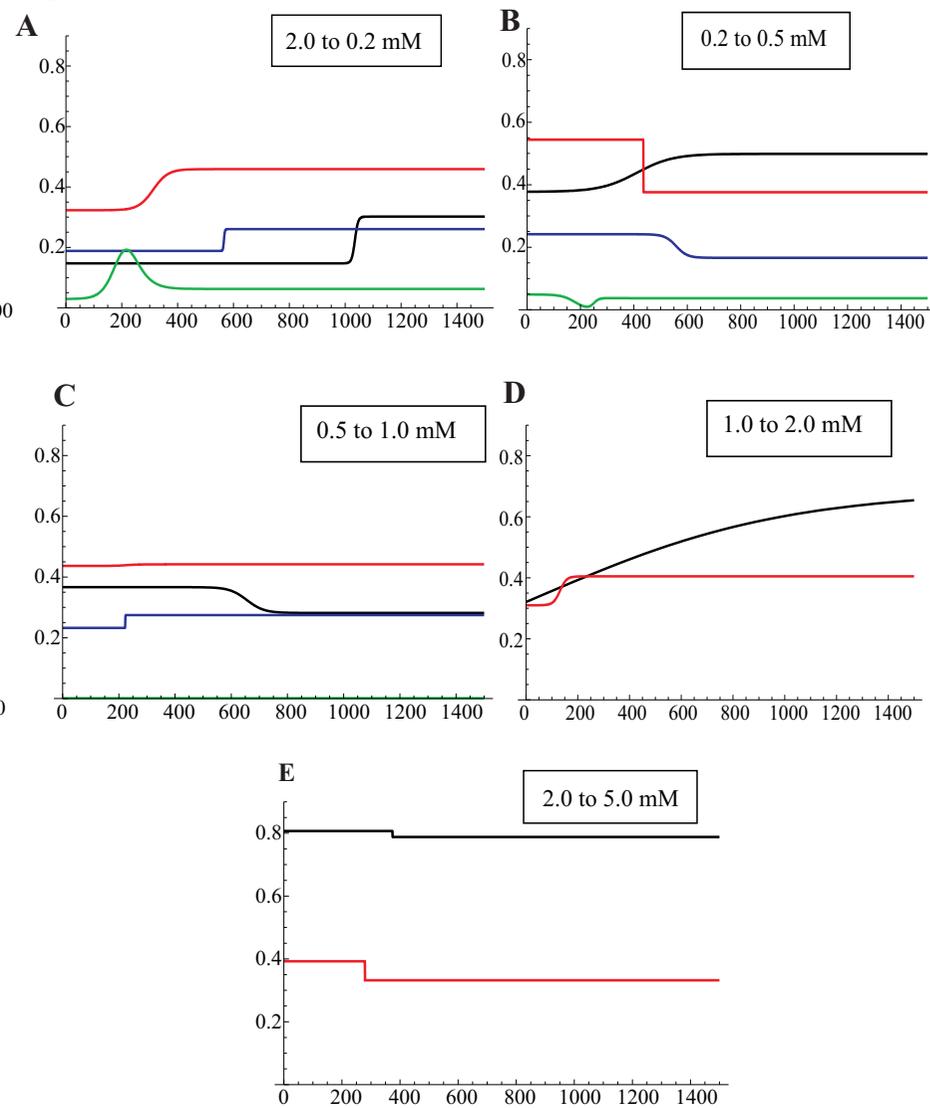


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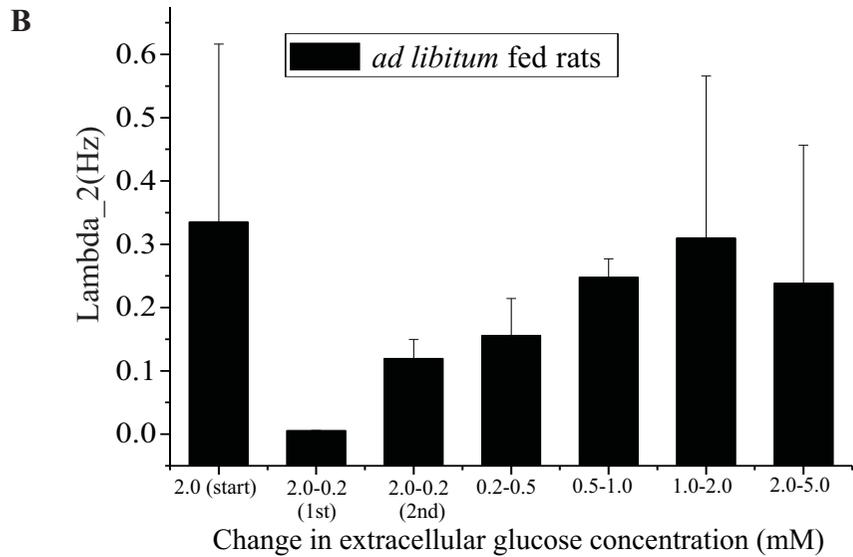
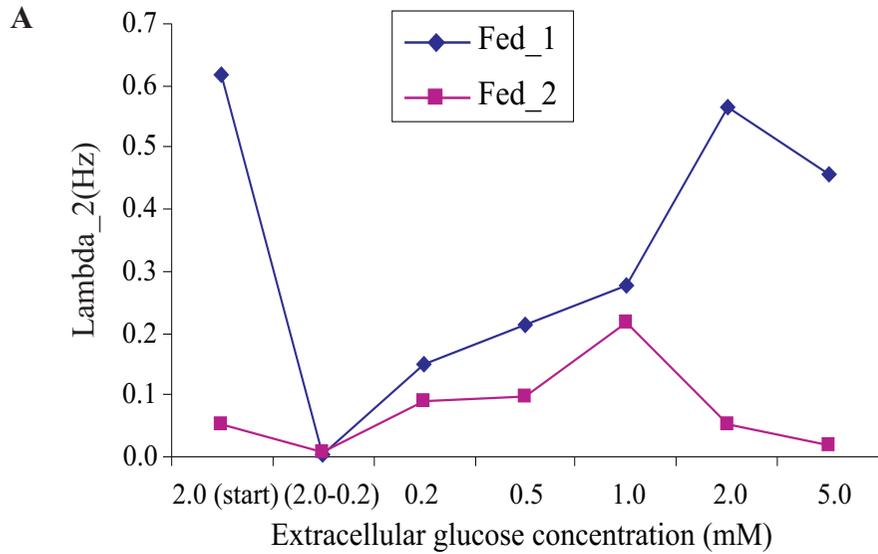


Figure 7.15

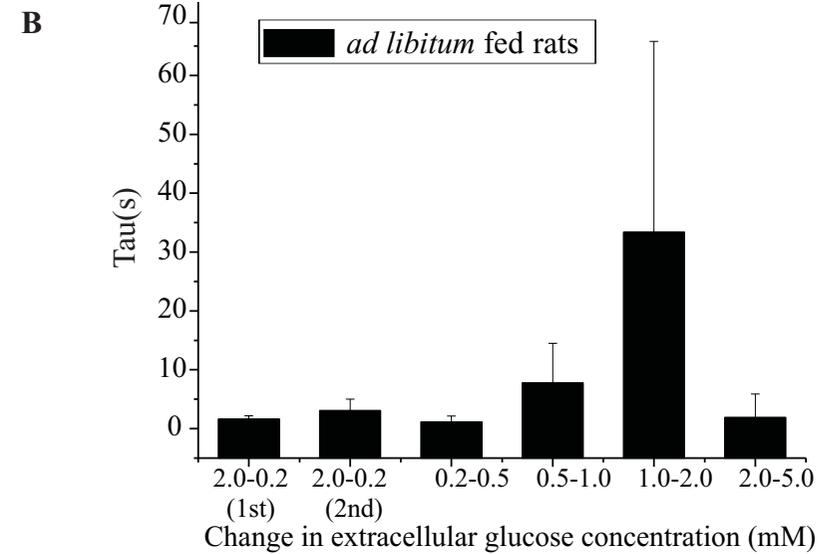
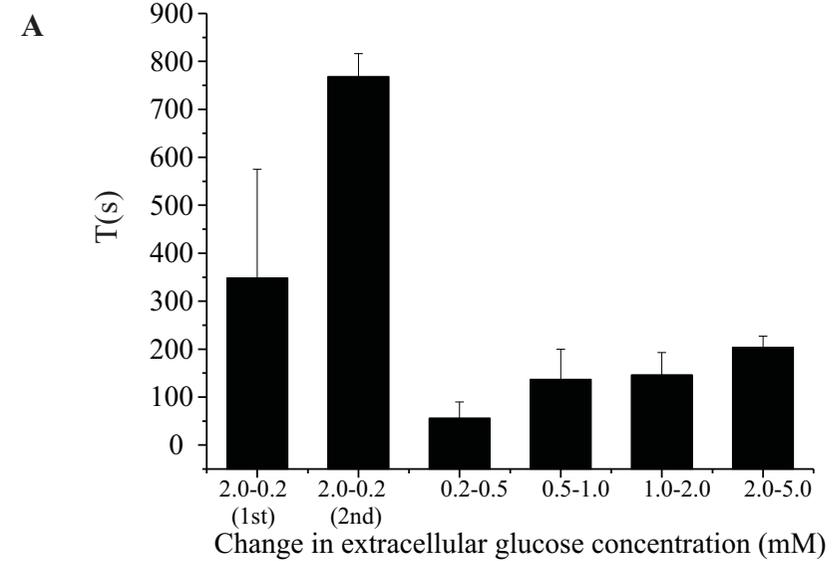


Figure 7.16

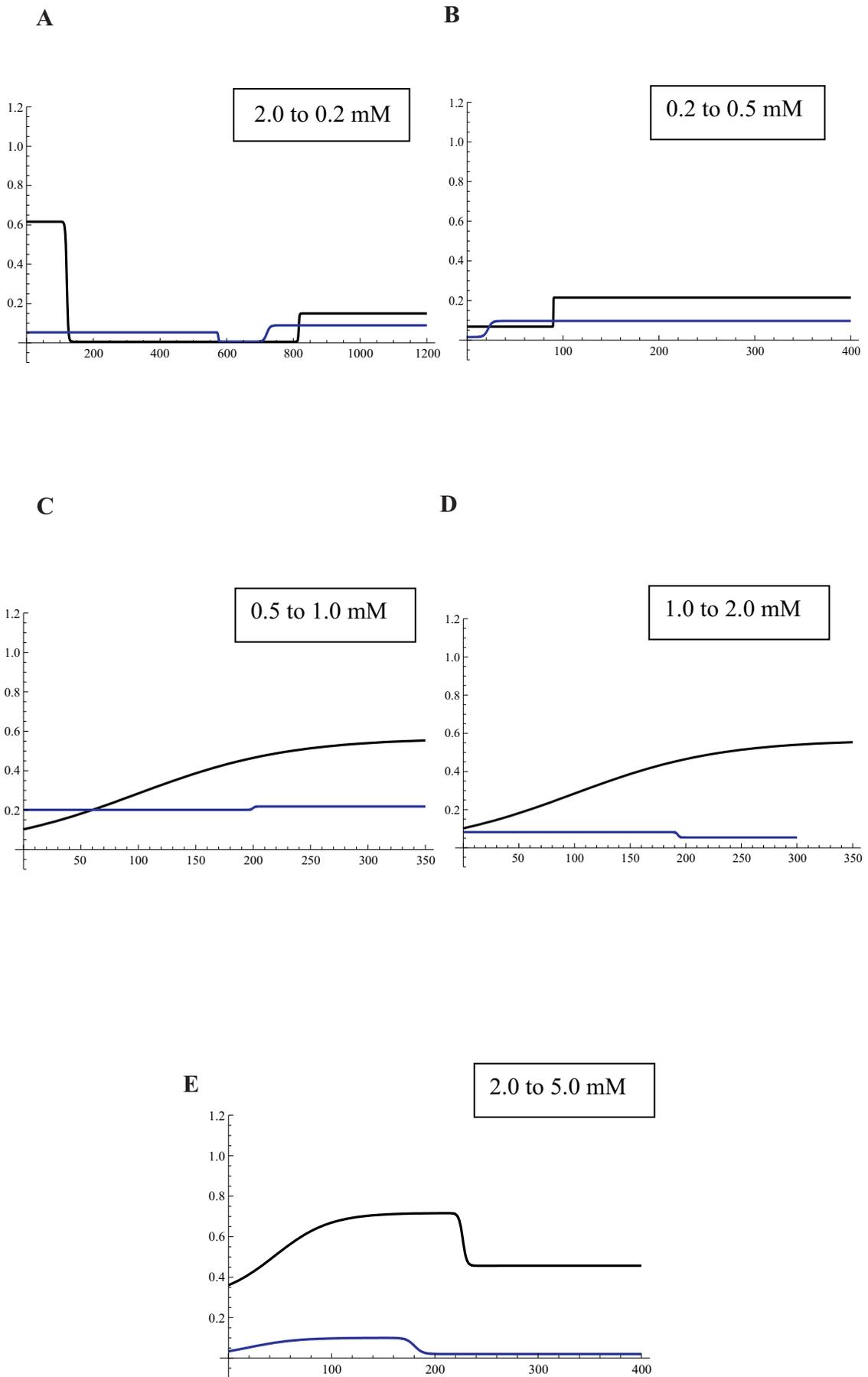


Figure 7.17

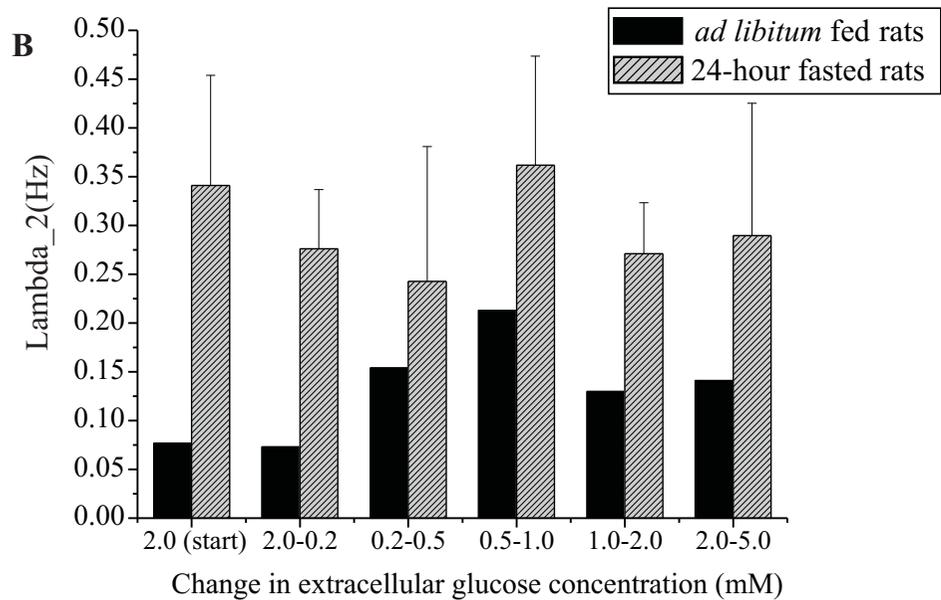
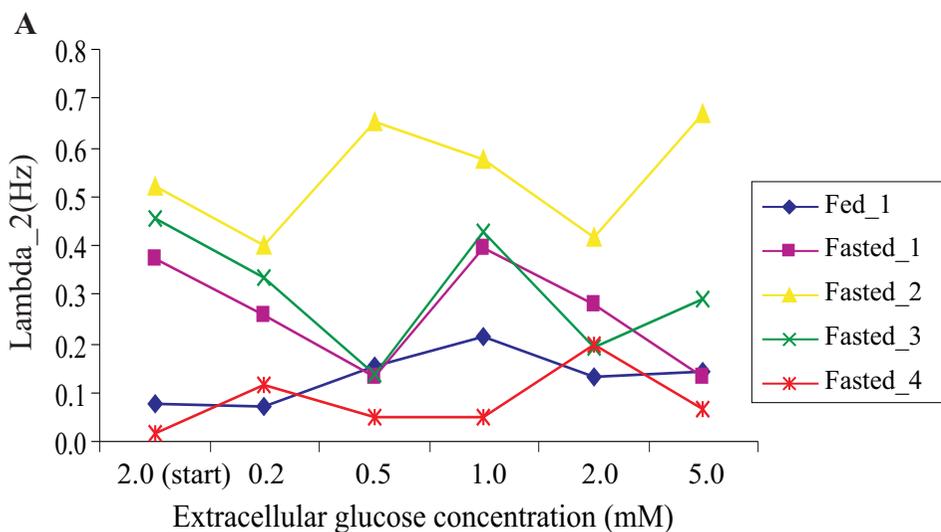


Figure 7.18

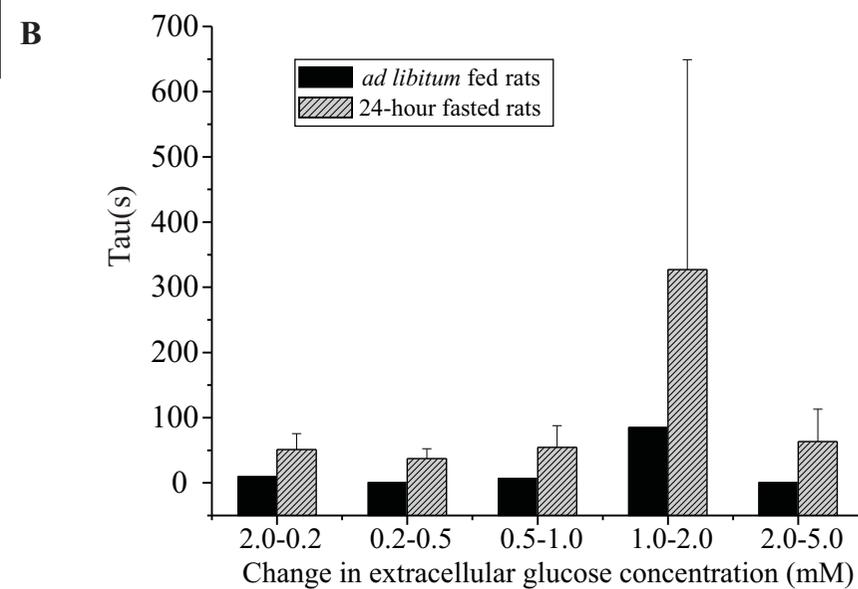
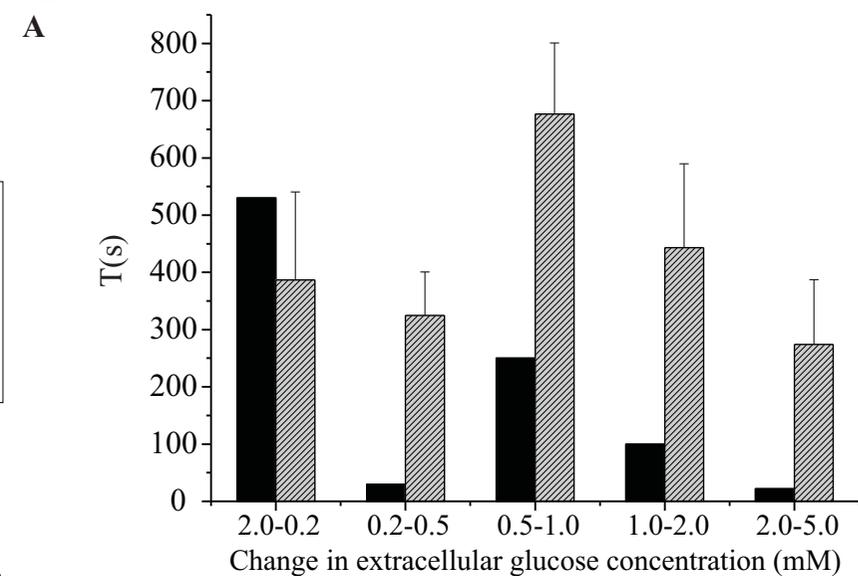


Figure 7.19

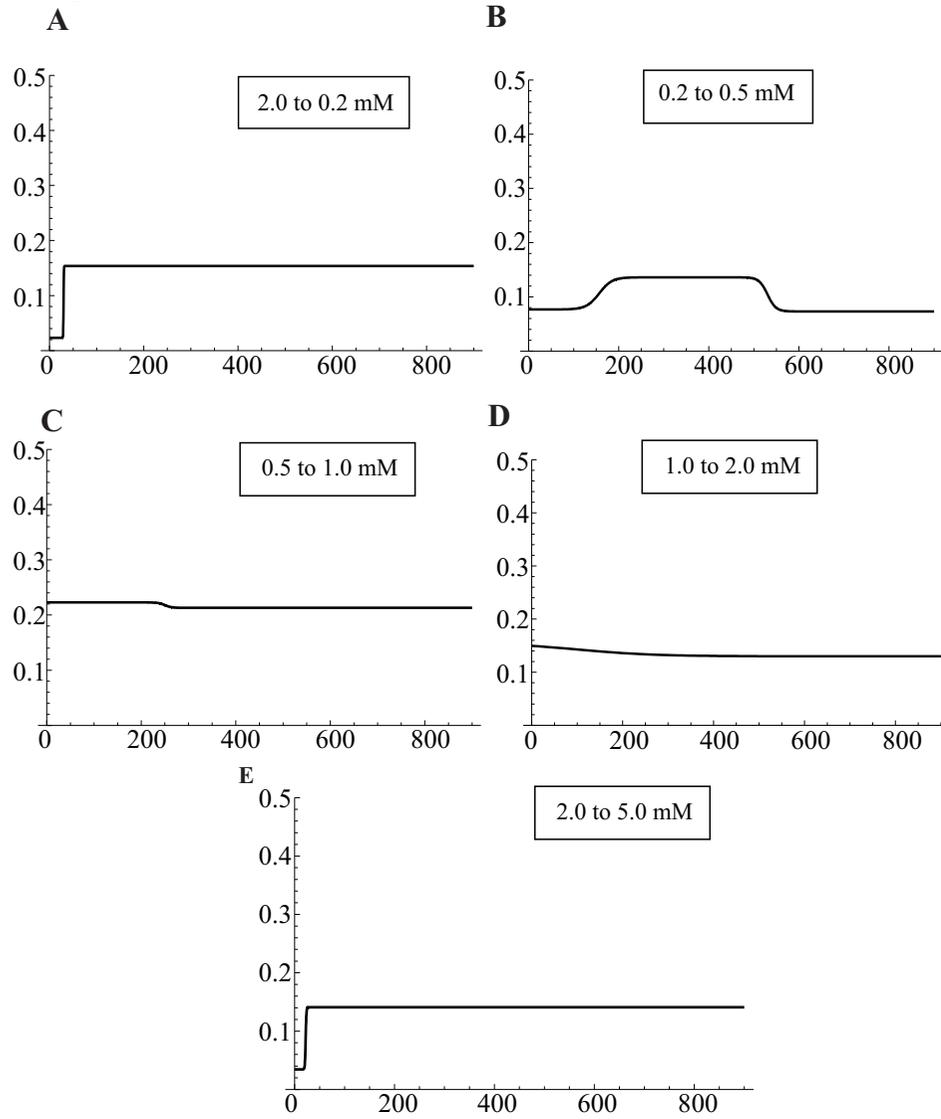


Figure 7.20

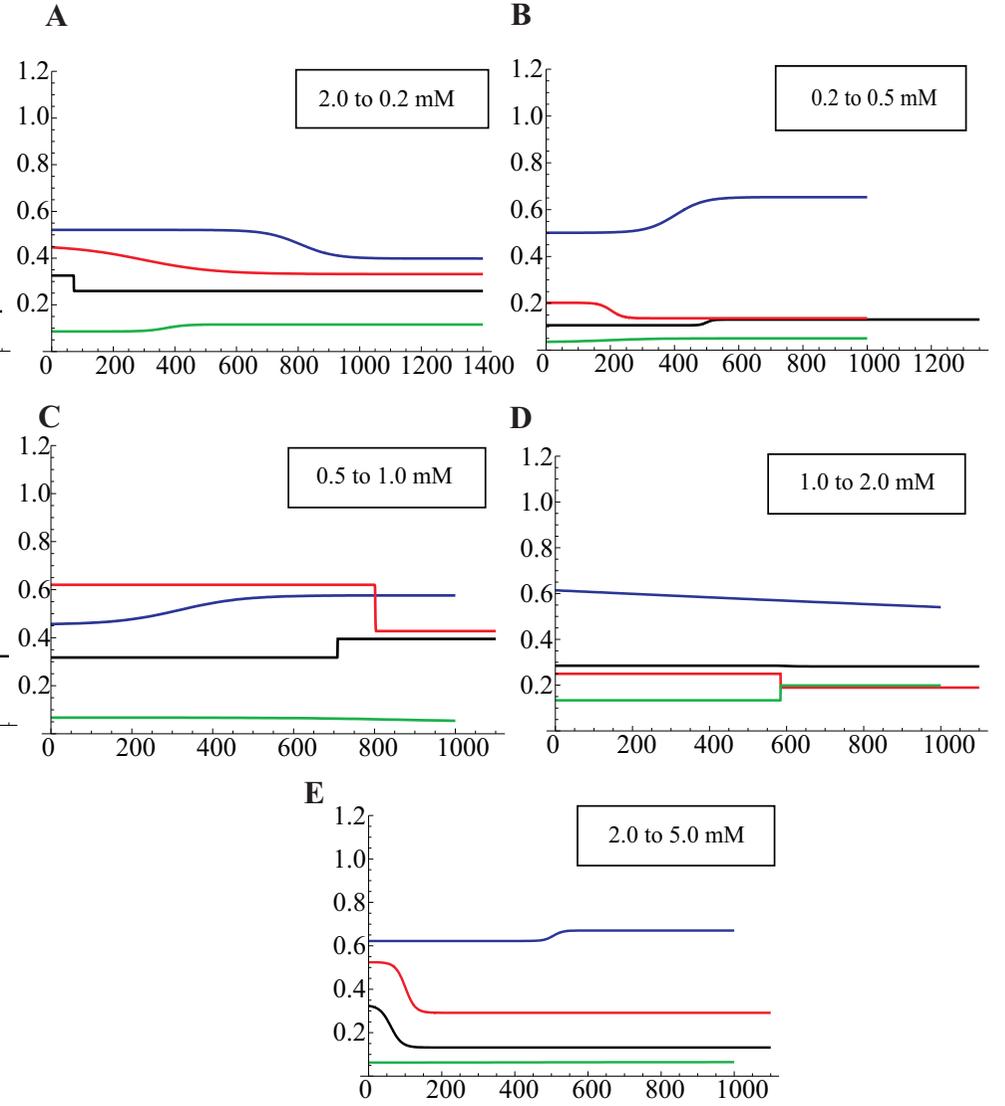


Table 7.1 Average of all parameters of neurones (inhibition without reversal) recorded in both *ad libitum* fed and 24-hour fasted rats

Extracellular Glucose concentrations (mM)	Parameters											
	λ_1			λ_2			τ			T		
	Fed	Fasted	WMW- test	Fed	Fasted	WMW- test	Fed	Fasted	WMW- test	Fed	Fasted	WMW- test
2.0 – 0.2	0.602 ± 0.158	0.350	-	0.114 ± 0.052	1.53 x 10 ⁻⁶	-	101 ± 14	67	-	137 ± 50	264	-
0.2 – 0.5	0.038 ± 0.034	-		0.030 ± 0.021	-		10 ± 9.9	-		121 ± 9.4	-	
0.5 – 1.0	0.014 ± 0.010	-		0.010 ± 0.006	-		11 ± 5.6	-		176± 34.1	-	
1.0 – 2.0	0.017 ± 0.017	-		0.002 ± 0.002	-		23	-		161	-	
2.0 – 5.0	0.009 ± 0.009	-		0.008 ± 0.008	-		10	-		150	-	

Table 7.2 Average of all parameters of neurones (inhibition with reversal) recorded in both *ad libitum* fed and 24-hour fasted rats

Extracellular Glucose concentrations (mM)	Parameters											
	λ_1			λ_2			τ			T		
	Fed	Fasted	WMW- test	Fed	Fasted	WMW- test	Fed	Fasted	WMW- test	Fed	Fasted	WMW- test
2.0 – 0.2	0.327 ± 0.278	0.328 ± 0.083	0.285	0.079 ± 0.052	0.087 ± 0.025	0.285	213 ± 201	97 ± 36	0.356	215 ± 215	413 ± 106	0.200
0.2 – 0.5	0.051 ± 0.044	0.041 ± 0.021	0.141	0.154 ± 0.093	0.268 ± 0.100	0.341	14 ± 13	120 ± 65	0.167	78 ± 5	470 ± 53	<i>P</i> < 0.05
0.5 – 1.0	0.114 ± 0.073	0.168 ± 0.077	0.158	0.262 ± 0.077	0.424 ± 0.224	0.264	23 ± 42	42 ± 14	0.264	226 ± 75	562 ± 175	0.115
1.0 – 2.0	0.167 ± 0.062	0.306 ± 0.146	0.452	0.457 ± 0.136	0.375 ± 0.119	0.452	14 ± 13	75 ± 49	0.143	82 ± 27	486 ± 155	<i>P</i> < 0.01
2.0 – 5.0	0.286 ± 0.002	0.108 ± 0.053	0.067	0.258 ± 0.030	0.176 ± 0.113	0.267	7 ± 7	116 ± 75	0.133	115 ± 11	843 ± 289	0.267

Table 7.3 Average of all parameters of neurones (excitation) recorded in both *ad libitum* fed and 24-hour fasted rats

Extracellular Glucose concentrations (mM)	Parameters											
	λ_1			λ_2			τ			T		
	Fed	Fasted	WMW- test	Fed	Fasted	WMW- test	Fed	Fasted	WMW- test	Fed	Fasted	WMW- test
2.0– 0.2	0.077 ± 0.041	0.172 ± 0.061	0.114	0.186 ± 0.073	0.271 ± 0.082	0.429	18 ± 9	16 ± 7	0.429	459 ± 149	529 ± 185	0.429
0.2 – 0.5	0.184 ± 0.084	0.303 ± 0.105	0.314	0.301 ± 0.217	0.269 ± 0.104	0.429	39 ± 30	25 ± 15	0.429	263. ± 35	414 ± 63	0.114
0.5 – 1.0	0.162 ± 0.133	0.259 ± 0.096	0.314	0.230 ± 0.174	0.250 ± 0.092	0.429	14 ± 14	18 ± 9	0.600	164 ± 43	369 ± 143	0.100
1.0 – 2.0	0.061 ± 0.033	0.155 ± 0.155	0.400	0.048 ± 0.024	0.545 ± 0.140	0.100	9 ± 3	243 ± 231	0.167	132 ± 37	96 ± 35	0.333
2.0 – 5.0	0.015 ± 0.009	0.600 ± 0.207	0.100	0.028 ± 0.015	0.560 ± 0.228	0.100	6 ± 2	0.1 ± 0.06	0.167	148 ± 45	327± 48	0.167

Table 7.4 Average of all parameters of neurones (rapidly adapting) recorded in *ad libitum* fed rats

Extracellular Glucose concentrations (mM)	Parameters						
	<i>ad libitum</i> fed rats						
	λ_1	λ_2	λ_3	τ_1	τ_2	T_1	T_2
2.0 – 0.2	0.335 ± 0.282	0.006 ± 0.0000377	0.119 ± 0.030	1.600 ± 0.6	3 ± 2	348 ± 227	768 ± 48
0.2 – 0.5	0.042 ± 0.026	0.156 ± 0.059	-	1.120 ± 1.031	-	56 ± 34	-
0.5 – 1.0	0.142 ± 0.059	0.248 ± 0.030	-	8 ± 7	-	137 ± 63	-
1.0 – 2.0	0.041 ± 0.041	0.310 ± 0.256	-	33 ± 32	-	146 ± 47	-
2.0 – 5.0	0.150 ± 0.145	0.238 ± 0.218	-	3 ± 1	-	204 ± 23	-

Table 7.5 Average of all parameters of neurones (no response) recorded in both *ad libitum* fed and 24-hour fasted rats

Extracellular Glucose concentrations (mM)	Parameters											
	λ_1			λ_2			τ			T		
	Fed	Fasted	WMW- test	Fed	Fasted	WMW- test	Fed	Fasted	WMW- test	Fed	Fasted	WMW- test
2.0 – 0.2	0.077	0.347 ± 0.096	-	0.073	0.276 ± 0.061	-	9	51 ± 25	-	530	387 ± 154	-
0.2 – 0.5	0.023	0.211 ± 0.103	-	0.154	0.243 ± 0.138	-	0.4	37 ± 15	-	30	325 ± 76	-
0.5 – 1.0	0.223	0.365 ± 0.117	-	0.213	0.362 ± 0.112	-	7	54 ± 34	-	250	676 ± 124	-
1.0 – 2.0	0.156	0.371 ± 0.151	-	0.130	0.271 ± 0.052	-	85	327 ± 322	-	100	443 ± 147	-
2.0 – 5.0	0.034	0.384 ± 0.124	-	0.141	0.290 ± 0.136	-	0.7	63 ± 50	-	22	274 ± 113	-