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NUMERICAL SIMULATION OF DIFFERENTIAL EFFECT OF INTRINSIC GROWTH RATE PARAMETER ON BIODIVERSITY TYPE

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Abstract
The numerical simulation of a differential effect of intrinsic growth rate parameters on biodiversity type was investigated. To facilitate the research work, a continuous system of non-linear first-order ordinary differential equations, indexed by appropriate initial conditions, was considered. A MATLAB ordinary differential equation (ODE45) numerical scheme was used to generate the data needed for the analysis. The key results of the investigation predict biodiversity loss due to a decreased variation of the intrinsic growth rates together and also predict biodiversity gain due to an increased variation of the intrinsic growth rates together.

Keywords: Numerical Simulation, Model Equations, Biodiversity, Intrinsic Growth Rate.

Introduction
One of the processes for understanding the interaction between two legumes, such as cowpea and groundnut, depends on constructing a deterministic mathematical model with the structure of a logistic model formation. This model is defined by two intrinsic growth rate parameter values, two intra-species coefficients, initial conditions, and the length of the growing season. Building upon previous studies by Ekaka-a (2009), Ekaka-a et al. (2017), Atsu and Ekaka-a (2017), De Mazancourt et al. (2013), Troost et al. (2007), Ford et al. (2010), Mba (2021), Mba et al. (2021), and Ajala (2002), the examination of how variations in model parameters affect biodiversity is an ongoing area of research. In this study, we aim to discover the differential effects of the intrinsic growth rate parameter value on the extent of biodiversity gain and loss using the ordinary differential equations of order 45 (ODE 45).

Materials and Methods
To achieve the aim and objective of this present study a system of non-linear first-order ordinary differential equations indexed by the appropriate initial condition as given by Ekaka-a et al. (2017) has been considered and extended. It is an ordinary differential equation because it involves derivatives concerning a single independent variable, Emenalo (2013), Ekaka-a et al. (2013), Fair, (1983), Chidume, (1984), Jiri (2010), Stewart, (2008), Winter (2007a) and Winter (2007b).

$$\frac{dC(t)}{dt} = \propto_1 C - \beta_1 C^2 + r_1 CG - k_1 C^2 G \qquad (1)$$
$$\frac{dC(t)}{dt} = \propto_2 G - \beta_2 G^2 + r_2 CG - k_2 CG^2 \qquad (2)$$

For this present study equations (1) and (2) by including a random perturbation variation, the generalised non-linear first-order ordinary differential equations will have the following mathematical structure:

$$\frac{dC(t)}{dt} = \propto_1 C - \beta_1 C^2 + r_1 CG - k_1 C^2 G + \left(r_{n1}(rand(1))\right) \qquad (3)$$
$$\frac{dC(t)}{dt} = \propto_2 G - \beta_2 G^2 + r_2 CG - k_2 C^2 G + \left(r_{n1}(rand(1))\right) \qquad (4)$$

With the initial condition C(o) = Co > 0 and G(o) >0 C(o) =Co >o and G(o)=Go >o
Where
C(t) defines the biomass of the cowpea legumes at time (t) in the unit of days
G(t) defines the biomass of groundnut legume at time (t) in units of days.

$\propto_1$ defines the intrinsic growth rates of the cowpea legume.
$\propto_2$ defines the intrinsic growth rate of the groundnut legume.
B_1 defines the intra-competition co-efficient of cowpea and cowpea legume
B_2 defines the intra-competition co-efficient of groundnut and groundnut legumes
Define the r_1 and r_2 defines k_1 and k_2 the disease inhibiting factors that affect the yield 0.0446, β_1 =0.006902, β_2 = 0.0133, r_1 = 0.018, r_2 =0.018, $k_1 = k_2$ =0.2of cowpea and groundnut respectively.
We have utilized the following parameter values $\propto_1$ = 0.0225, $\propto_2$ =0.0446

Due to the magnitude of the sample size of the data which we have used, it makes sense to apply a computationally efficient method of ordinary differential equation 45(ODE45) to compute the effect of decrease and increase of differential variation of the intrinsic growth rates of the cowpea and groundnut biomass on the prediction of biodiversity type using a non-linear first order ordinary dynamic system. The study coded, debug and run the dynamical system.

Results

The full results of this study are presented in Tables 1-6. For this numerical simulation result, we have used the following explanation for each column of data sets (see appendix). First Column represent time-dependent variation from t = 0, to t = 19. The second column specifies the changing biomass of cowpeas when all the model parameter values are fixed with the initial condition value of 0.02 grams per area of grass cover. The third column specifies changing modified cowpea biomass due to a decreased or increased variation of the intrinsic growth rate value of 0.0225 and 0.0446 together with the same initial condition. The fourth column specifies the estimated cowpea biomass metric function which depends on the changing. Length of the growing season in units of months. The fifth column specifies the impact of variation of the growth rates together on the biodiversity. The sixth column specifies the changing biomass of groundnut when all the model parameter values are fixed with the initial condition of 0.02. The seventh column specifies changing modified groundnut biomass due to a decrease or increase variation of intrinsic growth rate value of 0.0225 and 0.044 together with the same initial condition value of 0.02. The eighth column specifies the estimated groundnut biomass metric function which depends on the changing length of growing season in units of months. The ninth column specifies the impact of the variation of the growth rate together on the biodiversity.

Calculation of the lower limit and upper limit of the bifurcation interval in terms of the growth rate parameter values of 0.0225 and 0.0446 of cowpea and groundnut legumes when the length of the growing season is twenty (20) months

1. (0.0225)(0.9999) = 0.02249775; (0.0225)(1.01) = 0.022725
2. (0.0446) (0.9999)= 0.04459554; (0.0446)(1.01) = 0.045046

Discussion

As shown in Table 1 through Table 6, a close look at these first five tables clearly shows that a differential decrease in the intrinsic growth rates of cowpea and groundnut biomass predicts biodiversity loss as a differential increase in the intrinsic growth rates of two legumes of cowpea and groundnut predict biodiversity gain. The simulation result also reviewed that a differential decrease in intrinsic growth rates proved an increase in the matric function value as well as the Manhatan distance of the dynamical system under study; whereas a differential increase in intrinsic growth rates of cowpea and groundnut biomass proved a decrease of the matric function value of the Manhatan distance. The result also shows that a transition interval occurs or changes from biodiversity loss to biodiversity gain at a 99.99% differential decrease of the intrinsic growth rates to 101% differential increase in the intrinsic growth rates of the two legumes.

Conclusion

In this study, numerical simulation of a differential effect of intrinsic growth rates of cowpea and groundnut legume on the non-linear first-order ordinary differential equation of a dynamical system of a growth model was investigated, using the numerical method of ODE 45. The key results showed that a decrease in intrinsic growth rates together predicts biodiversity loss, small matric function, and Manhatan distance values. The result also shows that at certain variation values biofication or transition from biodiversity loss to biodiversity gain and vice versa. It is recommended that climate change should be properly guided to prevent variations that may lead to low crop yields and environmental perturbation.

References

Ajala, N., (2002). General topology, University of Lagos

Atsu J.U., & Ekaka-a E.N. (2017). Quatifying the impact of changing intrinsic growth rate on the biodiversity of the forest resource biomass: implications for the Cross River State forest resource at the Cross River National Park, South, 7 (1); 117-130.

Chidume, C.E.(1984). Functional analysis an Introduction to metric space. Department of Mathematics University of Nigeria, Nsukka.

De Mazancourt, C., Isbell, F., Larocque, A., Berendse, F., De Luca, E., Grace, J. B., ... & Loreau, M. (2013). Predicting ecosystem stability from community composition and biodiversity. *Ecology letters*, *16*(5), 617-625.

Ekaka E.N. (2017). Effect of the inter-species competition parameters on the onset of stability and degeneracy of co-existence steady-state solutions between competing populations. *Journal of the Nigerian Association of Mathematical Physics, 25* (2), 309-312.

Ekaka-a E.N. (2009). Computational and Mathematical Modeling of Plant species Interactions in a Harsh Climate, Ph.D Thesis, Department of Mathematics, The University of Liverpool Manchester, United Kingdom.

Ekaka-a, E.N. Chukwuocha E.O., Osaolube E., & Amadi E. H, (2013). Modeling mutualism. A mathematical model of plant species interactions in a harsh climate. *International Journal of Computational Engineering Research. 3*(9), 119-125

Emenalo, S.I (2013). *Differential equations*. Art Publishers

Fair, R.N. (1983). *Functional analysis with application.* Abanny State University Press.

Ford N. J., Lumb P.M, and Ekaka-a E.N (2010). Mathematical modeling of plant species dynamics alter community diversity-biomass stability relationships. *Ecol. Lett.*, *15* 1387-1396.

Jiri, L. (2010). Basic analysis, introduction to real analysis. Http://www.jirka.org/ra

Mba, D. O.(2021). Computational and mathematical modeling of functional analysis variables on the numerical simulation of biodiversity type postgraduate school: Ignatus Ajuru University of Education Rumuolumni, Port Harcourt. Nigeria.

Mba, D. O., Ekaka-a, E.N., Okereke, I.C., Nwagor, P., & Dickson, J.N. (2021). Computational and mathematical modeling of metric space properties on the prediction of biodiversity. *Journal of the Nigeria Association of Mathematical Physics, 55*, 197-200.

Mba D.O., Ekaka-a E.N., Nwagor P. Okereke I., & Dickson, J.N. (2020). Numerical simulation of functional analysis property on biodiversity. *Journal of the Nigerian Association of Mathematical Physics*, 55. 125-129.

Stewart, E.O. (2008). Introduction to real analysis. Cambridge University Press.

Troost, T. A.; Kovi, B.W, S.A.L. Kooijam M. (2007). Bifuration Analysis of ecological and evolutionary processes' in ecological. *Journal of Vegetation Science.*

Winter, R.M. (2007a). *Functional analysis and introduction.* Library of Mathematics New York

Winter, R.M. (2007b). *Introduction topology Dere van Farowe Zina Zhang*. University Press

Appendix

Table 1: Modelling the differential decreased effect of intrinsic growth rates on biodiversity type using the ODE 45 numerical method: 5 percent decrease in the intrinsic growth rates of 0.0225 and 0.0446 together

Time(t)	$CB_{old}(t)$	$CB_{new}(t)$	m_1	BL%	$GB_{old}(t)$	$GB_{new}(t)$	m_2	BL%
0.0000	0.0200	0.0200	0.0000	0.0000	0.0200	0.0200	0.0000	0.0000
1.0000	0.0205	0.0200	0.0004	2.1146	0.0209	0.0200	0.0009	4.1479
2.0000	0.0209	0.0200	0.0009	4.1839	0.0219	0.0201	0.0018	8.1226
3.0000	0.0214	0.0201	0.0013	6.2090	0.0228	0.0201	0.0027	11.9312
4.0000	0.0219	0.0201	0.0018	8.1908	0.0239	0.0202	0.0037	15.5808
5.0000	0.0224	0.0201	0.0023	10.1303	0.0250	0.0202	0.0048	19.0780
6.0000	0.0229	0.0201	0.0028	12.0282	0.0261	0.0202	0.0059	22.4290
7.0000	0.0234	0.0201	0.0032	13.8855	0.0273	0.0203	0.0070	25.6401
8.0000	0.0239	0.0202	0.0038	15.7030	0.0285	0.0203	0.0082	28.7171

9.0000	0.0244	0.0202	0.0043	17.4817	0.0298	0.0204	0.0094	31.6655
10.0000	0.0250	0.0202	0.0048	19.2223	0.0311	0.0204	0.0107	34.4908
11.0000	0.0256	0.0202	0.0053	20.9255	0.0325	0.0204	0.0121	37.1980
12.0000	0.0261	0.0202	0.0059	22.5923	0.0340	0.0205	0.0135	39.7922
13.0000	0.0267	0.0202	0.0065	24.2234	0.0355	0.0205	0.0150	42.2779
14.0000	0.0273	0.0203	0.0071	25.8196	0.0371	0.0205	0.0166	44.6598
15.0000	0.0279	0.0203	0.0076	27.3815	0.0388	0.0206	0.0182	46.9422
16.0000	0.0286	0.0203	0.0083	28.9099	0.0405	0.0206	0.0199	49.1292
17.0000	0.0292	0.0203	0.0089	30.4055	0.0424	0.0207	0.0217	51.2248
18.0000	0.0299	0.0203	0.0095	31.8690	0.0443	0.0207	0.0236	53.2329
19.0000	0.0305	0.0204	**0.0102**	**33.3011**	0.0463	0.0207	**0.0255**	**55.1570**

Table 2: Modelling the differential decreased effect of intrinsic growth rates on biodiversity type using the ODE 45 numerical method: 10 percent decrease in the intrinsic growth rates of 0.0225 and 0.0446 together

Time(t)	$CB_{old}(t)$	$CB_{new}(t)$	m_1	BL%	$GB_{old}(t)$	$GB_{new}(t)$	m_2	BL%
0.0000	0.0200	0.0200	0.0000	0.0000	0.0200	0.0200	0.0000	0.0000
1.0000	0.0205	0.0200	0.0004	2.0044	0.0209	0.0201	0.0008	3.9339
2.0000	0.0209	0.0201	0.0008	3.9682	0.0219	0.0202	0.0017	7.7120
3.0000	0.0214	0.0201	0.0013	5.8921	0.0228	0.0203	0.0026	11.3403
4.0000	0.0219	0.0202	0.0017	7.7770	0.0239	0.0203	0.0035	14.8249
5.0000	0.0224	0.0202	0.0022	9.6236	0.0250	0.0204	0.0045	18.1713
6.0000	0.0229	0.0202	0.0026	11.4328	0.0261	0.0205	0.0056	21.3851
7.0000	0.0234	0.0203	0.0031	13.2052	0.0273	0.0206	0.0067	24.4715
8.0000	0.0239	0.0203	0.0036	14.9417	0.0285	0.0207	0.0078	27.4355
9.0000	0.0244	0.0204	0.0041	16.6428	0.0298	0.0208	0.0090	30.2821
10.0000	0.0250	0.0204	0.0046	18.3095	0.0311	0.0208	0.0103	33.0158
11.0000	0.0256	0.0205	0.0051	19.9422	0.0325	0.0209	0.0116	35.6410
12.0000	0.0261	0.0205	0.0056	21.5418	0.0340	0.0210	0.0130	38.1622
13.0000	0.0267	0.0205	0.0062	23.1088	0.0355	0.0211	0.0144	40.5834
14.0000	0.0273	0.0206	0.0067	24.6439	0.0371	0.0212	0.0159	42.9086
15.0000	0.0279	0.0206	0.0073	26.1479	0.0388	0.0213	0.0175	45.1415
16.0000	0.0286	0.0207	0.0079	27.6212	0.0405	0.0214	0.0192	47.2859
17.0000	0.0292	0.0207	0.0085	29.0644	0.0424	0.0215	0.0209	49.3452
18.0000	0.0299	0.0208	0.0091	30.4783	0.0443	0.0216	0.0227	51.3227
19.0000	0.0305	0.0208	**0.0097**	**31.8634**	0.0463	0.0216	**0.0246**	**53.2218**

Table 3: Modelling the differential decreased effect of intrinsic growth rates on biodiversity type using the ODE 45 numerical method: 95 percent decrease in the intrinsic growth rates of 0.0225 and 0.0446 together

Time(t)	CBold(t)	CBnew(t)	m1	BL%	GBold(t)	GBnew(t)	m2	BL%
0.0000	0.0200	0.0200	0.0000	0.0000	0.0200	0.0200	0.0000	0.0000
1.0000	0.0205	0.0204	0.0000	0.1124	0.0209	0.0209	0.0000	0.2227
2.0000	0.0209	0.0209	0.0000	0.2247	0.0219	0.0218	0.0001	0.4449
3.0000	0.0214	0.0213	0.0001	0.3368	0.0228	0.0227	0.0002	0.6665
4.0000	0.0219	0.0218	0.0001	0.4488	0.0239	0.0237	0.0002	0.8875
5.0000	0.0224	0.0222	0.0001	0.5606	0.0250	0.0247	0.0003	1.1079
6.0000	0.0229	0.0227	0.0002	0.6722	0.0261	0.0257	0.0003	1.3277
7.0000	0.0234	0.0232	0.0002	0.7837	0.0273	0.0268	0.0004	1.5470
8.0000	0.0239	0.0237	0.0002	0.8950	0.0285	0.0280	0.0005	1.7656
9.0000	0.0244	0.0242	0.0002	1.0061	0.0298	0.0292	0.0006	1.9837
10.0000	0.0250	0.0247	0.0003	1.1171	0.0311	0.0304	0.0007	2.2011
11.0000	0.0256	0.0252	0.0003	1.2279	0.0325	0.0317	0.0008	2.4179
12.0000	0.0261	0.0258	0.0003	1.3385	0.0340	0.0331	0.0009	2.6341
13.0000	0.0267	0.0263	0.0004	1.4489	0.0355	0.0345	0.0010	2.8496
14.0000	0.0273	0.0269	0.0004	1.5592	0.0371	0.0360	0.0011	3.0645
15.0000	0.0279	0.0275	0.0005	1.6692	0.0388	0.0375	0.0013	3.2787
16.0000	0.0286	0.0281	0.0005	1.7791	0.0405	0.0391	0.0014	3.4923
17.0000	0.0292	0.0286	0.0006	1.8888	0.0424	0.0408	0.0016	3.7051
18.0000	0.0299	0.0293	0.0006	1.9983	0.0443	0.0425	0.0017	3.9173
19.0000	0.0305	**0.0299**	**0.0006**	**2.1076**	0.0463	**0.0444**	**0.0019**	**4.1288**

Table 4: Modelling the differential decreased effect of intrinsic growth on biodiversity type using the ODE 45 numerical method: 99.99 decrease in the intrinsic growth rates of 0.0225 and 0.0446 together

Time(t)	$CB_{old}(t)$	$CB_{new}(t)$	m_1	BL%	$GB_{old}(t)$	$GB_{new}(t)$	m_2	BL%
0.0000	0.0200	0.0200	0.0000	0.0000	0.0200	0.0200	0.0000	0.0000
1.0000	0.0205	0.0205	0.0000	0.0002	0.0209	0.0209	0.0000	0.0004
2.0000	0.0209	0.0209	0.0000	0.0004	0.0219	0.0219	0.0000	0.0009
3.0000	0.0214	0.0214	0.0000	0.0007	0.0228	0.0228	0.0000	0.0013
4.0000	0.0219	0.0219	0.0000	0.0009	0.0239	0.0239	0.0000	0.0018
5.0000	0.0224	0.0224	0.0000	0.0011	0.0250	0.0250	0.0000	0.0022
6.0000	0.0229	0.0229	0.0000	0.0013	0.0261	0.0261	0.0000	0.0027
7.0000	0.0234	0.0234	0.0000	0.0016	0.0273	0.0273	0.0000	0.0031
8.0000	0.0239	0.0239	0.0000	0.0018	0.0285	0.0285	0.0000	0.0036
9.0000	0.0244	0.0244	0.0000	0.0020	0.0298	0.0298	0.0000	0.0040
10.0000	0.0250	0.0250	0.0000	0.0022	0.0311	0.0311	0.0000	0.0045
11.0000	0.0256	0.0256	0.0000	0.0025	0.0325	0.0325	0.0000	0.0049
12.0000	0.0261	0.0261	0.0000	0.0027	0.0340	0.0340	0.0000	0.0053
13.0000	0.0267	0.0267	0.0000	0.0029	0.0355	0.0355	0.0000	0.0058
14.0000	0.0273	0.0273	0.0000	0.0031	0.0371	0.0371	0.0000	0.0062
15.0000	0.0279	0.0279	0.0000	0.0034	0.0388	0.0388	0.0000	0.0067
16.0000	0.0286	0.0286	0.0000	0.0036	0.0405	0.0405	0.0000	0.0071
17.0000	0.0292	0.0292	0.0000	0.0038	0.0424	0.0424	0.0000	0.0076

18.0000	0.0299	0.0299	0.0000	0.0040	0.0443	0.0443	0.0000	0.0080
19.0000	0.0305	**0.0305**	0.0000	**0.0043**	0.0463	**0.0463**	0.0000	**0.0084**

Table 5: Modelling the effect of the metric function and Manhattan distance on the biodiversity loss scenario using the ODE 45 numerical method: 101 percent increase in the intrinsic growth rates of 0.0225 and 0.0446 together

Time(t)	$CB_{old}(t)$	$CB_{new}(t)$	m_1	BL%	$GB_{old}(t)$	$GB_{new}(t)$	m_2	BL%
0.0000	0.0200	0.0200	0.0000	0.0000	0.0200	0.0200	0.0000	0.0000
1.0000	0.0205	0.0205	0.0000	0.0225	0.0209	0.0209	0.0000	0.0446
2.0000	0.0209	0.0209	0.0000	0.0450	0.0219	0.0219	0.0000	0.0892
3.0000	0.0214	0.0214	0.0000	0.0675	0.0228	0.0229	0.0000	0.1338
4.0000	0.0219	0.0219	0.0000	0.0900	0.0239	0.0239	0.0000	0.1784
5.0000	0.0224	0.0224	0.0000	0.1125	0.0250	0.0250	0.0001	0.2231
6.0000	0.0229	0.0229	0.0000	0.1350	0.0261	0.0262	0.0001	0.2677
7.0000	0.0234	0.0234	0.0000	0.1575	0.0273	0.0273	0.0001	0.3123
8.0000	0.0239	0.0239	0.0000	0.1800	0.0285	0.0286	0.0001	0.3569
9.0000	0.0244	0.0245	0.0000	0.2024	0.0298	0.0299	0.0001	0.4015
10.0000	0.0250	0.0250	0.0001	0.2249	0.0311	0.0313	0.0001	0.4461
11.0000	0.0256	0.0256	0.0001	0.2474	0.0325	0.0327	0.0002	0.4907
12.0000	0.0261	0.0262	0.0001	0.2699	0.0340	0.0342	0.0002	0.5353
13.0000	0.0267	0.0268	0.0001	0.2923	0.0355	0.0357	0.0002	0.5799
14.0000	0.0273	0.0274	0.0001	0.3148	0.0371	0.0374	0.0002	0.6244
15.0000	0.0279	0.0280	0.0001	0.3372	0.0388	0.0391	0.0003	0.6689
16.0000	0.0286	0.0287	0.0001	0.3597	0.0405	0.0408	0.0003	0.7134
17.0000	0.0292	0.0293	0.0001	0.3821	0.0424	0.0427	0.0003	0.7579
18.0000	0.0299	0.0300	0.0001	0.4045	0.0443	0.0446	0.0004	0.8024
19.0000	0.0305	**0.0307**	**0.0001**	**0.4269**	0.0463	**0.0467**	**0.0004**	**0.8468**

Table 6: Modelling the differential increased effect of intrinsic on biodiversity the ODE 45 numerical method: 102 percent increase in the intrinsic growth rates of 0.0225 and 0.0446 together

Time(t)	$CB_{old}(t)$	$CB_{new}(t)$	m_1	BL%	$GB_{old}(t)$	$GB_{new}(t)$	m_2	BL%

0.0000	0.0200	0.0200	0.0000	0.0000	0.0200	0.0200	0.0000	0.0000
1.0000	0.0205	0.0205	0.0000	0.0450	0.0209	0.0209	0.0000	0.0892
2.0000	0.0209	0.0209	0.0000	0.0900	0.0219	0.0219	0.0000	0.1785
3.0000	0.0214	0.0214	0.0000	0.1350	0.0228	0.0229	0.0001	0.2678
4.0000	0.0219	0.0219	0.0000	0.1801	0.0239	0.0240	0.0001	0.3572
5.0000	0.0224	0.0224	0.0001	0.2251	0.0250	0.0251	0.0001	0.4466
6.0000	0.0229	0.0229	0.0001	0.2701	0.0261	0.0262	0.0001	0.5361
7.0000	0.0234	0.0235	0.0001	0.3152	0.0273	0.0274	0.0002	0.6256
8.0000	0.0239	0.0240	0.0001	0.3602	0.0285	0.0287	0.0002	0.7151
9.0000	0.0244	0.0245	0.0001	0.4053	0.0298	0.0300	0.0002	0.8046
10.0000	0.0250	0.0251	0.0001	0.4503	0.0311	0.0314	0.0003	0.8942
11.0000	0.0256	0.0257	0.0001	0.4954	0.0325	0.0328	0.0003	0.9838
12.0000	0.0261	0.0263	0.0001	0.5405	0.0340	0.0344	0.0004	1.0734
13.0000	0.0267	0.0269	0.0002	0.5855	0.0355	0.0359	0.0004	1.1631
14.0000	0.0273	0.0275	0.0002	0.6305	0.0371	0.0376	0.0005	1.2527
15.0000	0.0279	0.0281	0.0002	0.6756	0.0388	0.0393	0.0005	1.3423
16.0000	0.0286	0.0288	0.0002	0.7206	0.0405	0.0411	0.0006	1.4319
17.0000	0.0292	0.0294	0.0002	0.7656	0.0424	0.0430	0.0006	1.5216
18.0000	0.0299	0.0301	0.0002	0.8106	0.0443	0.0450	0.0007	1.6111
19.0000	0.0305	**0.0308**	**0.0003**	**0.8556**	0.0463	**0.0470**	**0.0008**	**1.7007**

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