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A single acceptance sampling plan for the three-parameter Lindley distribution under a truncated life test is developed. For various consumer's confidence levels, acceptance numbers, and values of the ratio of the experimental time to the specified average lifetime, the minimum sample size important to assert a certain average lifetime are calculated. The operating characteristic (OC) function values as well as the associated producer's risks are also provided. A numerical example is presented to illustrate the suggested acceptance sampling plans.

Keywords: Acceptance sampling plan, three-parameter Lindley distribution, operating characteristic function, producer's risk, consumer's risk, truncated life test

Introduction

Acceptance sampling plan is a quality control decision procedure used when the cost in testing an item is high comparing to the cost of passing a defective item. It is an inspection procedure used by manufacturers, researchers etc., to determine whether to accept or reject a lot based on a pre-specified quality standards. The procedure is considered as a binomial experiment in which the random variable is the number of failures within a pre-determined time. Based on this experiment, the statistical decision is to reject a lot that contains large numbers of items; if the number of failures observed is greater than a specified acceptance number, "*c*"; otherwise it will be accepted. Drawing decision in this experiment has two risks: from one side, rejection a good lot, known as producer's risk, and acceptance of a bad lot, that known as the consumer's risk. The acceptance sampling plan should

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be designed such that both types of risks have a minimum value. In order to ensure this, many authors have tested this kind of sampling plans, taking into account different procedures, sampling techniques or distributions.

Aslam, Kundu, and Ahmad (2007), Aslam, Jun, et al. (2011), and Gui and Aslam (2017) developed acceptance sampling plan for a generalized and weighted exponential distribution, respectively. Al-Omari (2015) considered the time truncated acceptance sampling plans using the generalized inverted exponential distribution. Tsai and Wu (2006) suggested a single sampling plan when the life time follows generalized Rayleigh distribution. Al-Omari (2014) suggested a sampling plan for the three-parameter kappa distribution. Al-Omari (2016) for generalized inverse Weibull distribution. Al-Omari et al. (2017) proposed double acceptance sampling plan for exponentiated generalized inverse Rayleigh distribution. Al-Omari and Zamanzade (2017) introduced double acceptance sampling plan transmuted generalized inverse Weibull distribution. Malathi and Muthulakshmi (2017) developed acceptance sampling plans for truncated life test using Frechet distribution. Nehzad and Seifi (2017) proposed repetitive group sampling plan based on the process capability index.

The main aim of this research is to develop acceptance sampling plans for the three-parameter Lindley distribution (Abd El-Monsef, 2016) which is a generalization of the one-parameter Lindley distribution that suggested by Ghitany et al. (2008). To best of our knowledge that is this is the first paper considered an acceptance sampling plan for the three-parameter Lindley distribution.

Three-Parameter Lindley Distribution

In the context of Bayesian analysis, Lindley (1958) introduced a single parameter distribution and defined its probability density function (pdf) and cumulative distribution function (cdf) as

$$\mathrm{f}\left(z,\theta\right)=\frac{\theta^{2}}{\theta+1}\left(1+z\right)\mathrm{e}^{-\theta z};\quad z>0,\theta>0$$

$$\mathrm{F}\left(z,\theta\right)=1-\left(1+\frac{\theta z}{1+\theta}\right)\mathrm{e}^{-\theta z};\quad z>0,\theta>0$$

Shanker, Fesshaye, and Sharma (2016) used this distribution for modelling life time data. An extension to Lindley distribution has been made by Shanker and Mishra (2013) by adding another parameter to the distribution and name it by two-parameter Lindely distribution. Later, Abd El-Monsef (2016) proposed a three-parameter Lindley distribution; which we are interested in this article, and defined its probability density function as

$$\mathrm{f}_{\text{3P-L}}\left(z;\theta,\alpha,\beta\right)=\frac{\theta^{2}}{\theta+\alpha}\left[1+\alpha\left(z-\beta\right)\right]\mathrm{e}^{-\theta(z-\beta)}, \tag{1}$$

where $z > \beta \geq 0$, $\theta > 0$, $\alpha > 0$, and β is a location parameter. The cumulative distribution function corresponding to the pdf given in equation (1) is given by

$$\mathrm{F}_{\text{3P-L}}\left(z;\theta,\alpha,\beta\right)=1-\left[1+\frac{\alpha\theta\left(z-\beta\right)}{\theta+\alpha}\right]\mathrm{e}^{-\theta(z-\beta)}, \tag{2}$$

where $z > \beta \geq 0$, $\theta > 0$, and $\alpha > 0$.

Figures 1 and 2 show the shape of the pdf and cdf of the three-parameter Lindley distribution.

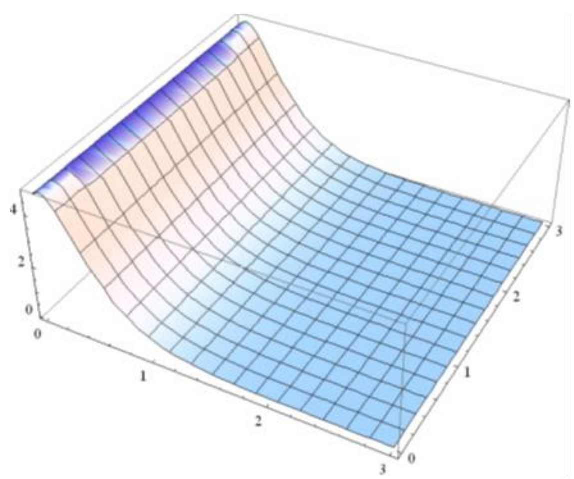

Figure 1. The pdf of the three-parameter Lindley distribution α = 3, β = 3, γ = 3, λ = –0.9, with θ = 3, β = 0.3, and α = 0.5

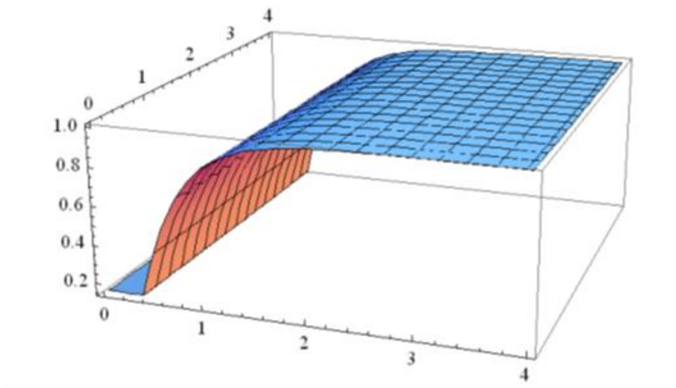

Figure 2. The cdf of the three-parameter Lindley distribution $\alpha = 3$, $\beta = 3$, $\gamma = 3$, $\lambda = -0.9$, with $\theta = 3$, $\beta = 0.3$, and $\alpha = 0.5$

The quantile function of the three-parameter Lindley distribution is

$$\mathrm{F}^{-1}(u) = \beta - \left(\frac{\alpha+\theta}{\alpha\theta}\right) - \frac{1}{\theta}\mathrm{W}_{-1}\left[(u-1)\left(\frac{\alpha+\theta}{\alpha}\right)\mathrm{e}^{-\left(\frac{\alpha+\theta}{\alpha}\right)}\right], \quad 0 < u < 1, \tag{3}$$

where $z > \beta \geq 0$, $\theta > 0$, $\alpha > 0$, and W_{-1} is the negative branch of the Lambert W function. The mean of the three-parameter Lindley distribution is given by

$$\mu_{\text{3P-L}} = \mathrm{E}(Z) = \frac{\theta(1+\beta\theta)+\alpha(2+\beta\theta)}{\theta(\alpha+\theta)} \tag{4}$$

with moment generating function

$$\mathrm{M}_z(t) = \frac{\theta^2}{\alpha+\theta}\left[\frac{\mathrm{e}^{t\beta}(\theta+\alpha-t)}{(t-\theta)^2}\right]. \tag{5}$$

The survival and hazard functions associated with equation (1), respectively, are given by

$$\begin{aligned}\mathrm{S}_{\text{3P-L}}(t;\theta,\alpha,\beta) &= 1-\mathrm{F}_{\text{3P-L}}(t;\theta,\alpha,\beta) \\ &= 1-\left[1+\frac{\alpha\theta(t-\beta)}{\theta+\alpha}\right]\mathrm{e}^{-\theta(t-\beta)}; \quad t > \beta\end{aligned} \tag{6}$$

and

$$\begin{aligned} \mathrm{h}_{\text{3P-L}}\left(t;\theta,\alpha,\beta\right) &= \frac{\mathrm{f}_{\text{3P-L}}\left(t;\theta,\alpha,\beta\right)}{\mathrm{S}_{\text{3P-L}}\left(t;\theta,\alpha,\beta\right)} \\ &= \frac{\theta^2\left[1+\alpha\left(t-\beta\right)\right]}{\left(\alpha+\theta\right)+\alpha\,\theta\left(t-\beta\right)}; \quad t>\beta \end{aligned} \tag{7}$$

The distribution is unimodal at

$$z_0 = \frac{\alpha-\theta+\alpha\theta\beta}{\alpha\theta}, \quad \alpha>0, \quad \text{and} \quad \beta>\frac{\theta-\alpha}{\alpha\theta}.$$

The variance of the distribution is

$$\sigma^2_{\text{3P-L}} = \frac{2\alpha^2+4\alpha\theta+\theta^2}{\theta^3\left(\alpha+\theta\right)^2}.$$

The maximum likelihood estimators of the three-parameter Lindley distribution parameters can be obtained by solving the following equations simultaneously:

$$\begin{aligned} -\frac{n}{\theta+\alpha}+\frac{2n}{\theta}+n\left(\beta-\overline{z}\right)&=0 \\ -\frac{n}{\theta+\alpha}+\sum_{i=1}^{n}\frac{z_i-\beta}{1+\alpha\left(z_i-\beta\right)}&=0 \\ -n\theta+\sum_{i=1}^{n}\frac{\alpha}{1+\alpha\left(z_i-\beta\right)}&=0 \end{aligned}$$

Other properties of the three-parameter Lindley distribution can be found in Abd El-Monsef (2016). It worth to say, a different three-parameter Lindley distribution is proposed by Shanker, Kumar, et al. (2017).

Design of the Acceptance Sampling Plan

Assume the life time of the submitted products follows a three-parameter Lindley distribution given in equation (1). An acceptance sampling plan based on truncated life tests consists of:

(1) The number of units n to be drawn from the lot.
(2) An acceptance number c, where if at most c failures out of n occur at the end of the pre-determined time t_0, the lot is accepted.
(3) The ratio t_0 / μ_0, where μ_0 is the specified mean (quality parameter) life and t_0 is the maximum test duration.

Minimum Sample Size

The size of the lot is assumed to be very large (to be considered infinite) so that the binomial distribution can be applied. Assume the consumer's risk is determined to be at most $1 - P^*$, i.e., the probability that the real mean life μ is less than μ_0, does not exceed $1 - P^*$. The probability of acceptance a lot is calculated using the inequality

$$\sum_{w=0}^{c} \binom{n}{w} p^w (1-p)^{n-w} \leq 1 - P^*, \tag{8}$$

where $P^* \in (0, 1)$ and

$$p = \mathrm{F}(t; \mu_0) = 1 - \left[1 + \frac{\alpha\theta(t_0 - \beta)}{\theta + \alpha}\right] \mathrm{e}^{-\theta(t_0 - \beta)}$$

is the probability of a failure observed within the time t which depends only on the ratio t / μ_0.

If the number of observed failures within the time t is at most c, then from equation (8) conclude $\mathrm{P}[\mathrm{F}(t; \mu) \leq \mathrm{F}(t; \mu_0)] = P^*$ if and only if $\mathrm{P}(\mu_0 \leq \mu) = P^*$. The rejection or acceptance of the lot are equivalent to the rejection or acceptance of the hypothesis H_0: $\mu_0 \leq \mu$.

The minimum values of n in equation (8) are calculated for $t / \mu_0 = 0.628$, 0.942, 1.257, 1.571, 2.356, 3.141, 3.927, and 4.712, and the values of P^* are 0.75, 0.90, 0.95, and 0.99. The selection of these values of t / μ_0 and P^* are to compare our results with corresponding values given in Gupta and Groll (1961), Baklizi and

El Masri (2004), Kantam et al. (2001), and Al-Nasser and Al-Omari (2013). The smallest sample sizes satisfying inequality (8) for t / μ_0, P^*, and c = 0, 1, 2,…, 10 for the parameters $\beta = 0.9$, $\alpha = 25$, and $\theta = 0.1$ are presented in Table 1.

Operating Characteristic Function

The operating characteristic function of the sampling plan (n, c, t / μ_0) gives the probability of accepting the lot. For truncated acceptance sampling plan the probability is given by

$$\mathrm{L}(p) = \sum_{x=w}^{c} \binom{n}{w} p^{w} (1-p)^{n-w} , \tag{9}$$

where $p = \mathrm{F}(t; \mu)$ is considered as a function of the mean μ. The operating characteristic function values as a function of $\mu \geq \mu_0$ for the sampling plan (n, $c = 2$, t / μ_0) are given in Table 2 for $\beta = 0.9$, $\alpha = 25$, and $\theta = 0.1$ in the three-parameter Lindley distribution. At fixed time t, the operating characteristic is a decreasing function in the probability P, while P itself is a monotonically decreasing function of $\mu \geq \mu_0$. The choice of c and n can be based on the operation characteristic function for a given $P^* \in (0, 1)$ and t / μ_0.

Producer’s Risk

The producer's risk (PR) is the probability of rejecting the lot when $\mu \geq \mu_0$. For a given value of the producer's risk, say ε, a researcher may be interested in knowing the value of μ / μ_0 which will assert the producer's risk to be at most ε. Therefore, μ / μ_0 is the smallest positive number for which $p = \mathrm{F}\left(\frac{t}{\mu_0}; \frac{\mu_0}{\mu}\right)$ satisfies the inequality

$$\sum_{w=0}^{n} \binom{n}{w} p^{w} (1-p)^{n-w} \geq 1-\varepsilon . \tag{10}$$

For a given acceptance sampling plan (n, c, t / μ_0), at a determined confidence level P^*, the minimum values of μ / μ_0 satisfying inequality (9) are obtained and given in Table 3 for $\beta = 0.9$, $\alpha = 25$, and $\theta = 0.1$ in the three-parameter Lindley distribution.

Descriptions of Tables

Assume the life time of a product follows a three-parameter Lindley distribution. Let $T \sim f_{3P\text{-}L}(z; \theta, \alpha, \beta)$ with $\beta = 0.9$, $\alpha = 25$, and $\theta = 0.1$. Assume that the researcher wants to establish that the true unknown mean life is at least 1000 hours (μ_0) with confidence level $P^* = 0$, and that the life test will be terminated at $t = 628$ hours. Therefore, for an acceptance number $c = 2$, the required sample size n is obtained in Table 1 to be 15. That is, if within 628 hours no more than 15 failures are observed, then the researcher can confirm with confidence 0.90 that the mean life is at least 1000.

For the sampling plan ($n = 15$, $c = 2$, $t / \mu_0 = 0.628$), the operating characteristic values from Table 2 are

μ / μ_0	2	4	6	8	10	12
OC	0.803512	0.995847	0.999854	0.999994	1	1

This means that if the mean life is twice the specified average life ($\mu / \mu_0 = 2$) then the producer's risk is 0.196488, while the producer's risk is about zero for $\mu / \mu_0 \geq 6$.

Table 3 can be used to find the value of μ / μ_0 for various choices of t / μ_0 and c such that the producer's risk may not exceed 0.05. As an example, the value of μ / μ_0 is 3.4 for $c = 2$, $t / \mu_0 = 0.628$, and $P^* = 0.9$. This indicates the product must have a mean life of 3.4 times the specified mean life in order to accept the lot with probability 0.90.

Table 1. Minimum sample size to assert that the mean life exceeds a given value μ_0 with probability P^* and acceptance number c based on binomial probabilities when $\beta = 0.9$, $\alpha = 25$, and $\theta = 0.1$

		t / μ_0							
P^*	c	0.628	0.942	1.257	1.571	2.356	3.141	3.927	4.712
0.75	0	13	6	4	3	2	1	1	1
0.75	1	26	12	8	6	4	3	2	2
0.75	2	38	18	11	8	5	4	4	3
0.75	3	49	24	15	11	7	5	5	4
0.75	4	60	29	18	14	9	7	6	5
0.75	5	71	34	22	16	10	8	7	7
0.75	6	82	40	25	19	12	9	8	8
0.75	7	93	45	29	21	14	11	9	9
0.75	8	104	50	32	24	15	12	11	10
0.75	9	114	55	35	26	17	13	12	11
0.75	10	125	60	39	29	18	15	13	12

Table 1 (continued).

		t / μ_0							
P^*	c	0.628	0.942	1.257	1.571	2.356	3.141	3.927	4.712
0.90	0	6	3	2	2	1	1	1	1
0.90	1	11	6	4	3	3	2	2	2
0.90	2	15	9	6	5	4	3	3	3
0.90	3	19	11	8	6	5	4	4	4
0.90	4	23	13	10	8	6	5	5	5
0.90	5	27	15	11	9	7	6	6	6
0.90	6	30	18	13	11	8	7	7	7
0.90	7	34	20	14	12	9	9	8	8
0.90	8	38	22	16	13	11	10	9	9
0.90	9	41	24	18	15	12	11	10	10
0.90	10	45	26	19	16	13	12	11	11
0.95	0	4	3	2	2	1	1	1	1
0.95	1	7	4	3	3	2	2	2	2
0.95	2	10	6	5	4	3	3	3	3
0.95	3	12	8	6	5	4	4	4	4
0.95	4	15	9	7	6	5	5	5	5
0.95	5	17	11	9	8	6	6	6	6
0.95	6	19	12	10	9	8	7	7	7
0.95	7	21	14	11	10	9	8	8	8
0.95	8	24	15	12	11	10	9	9	9
0.95	9	26	17	14	12	11	10	10	10
0.95	10	28	18	15	13	12	11	11	11
0.99	0	4	3	2	2	1	1	1	1
0.99	1	7	4	3	3	2	2	2	2
0.99	2	9	6	5	4	3	3	3	3
0.99	3	11	7	6	5	4	4	4	4
0.99	4	13	8	7	6	5	5	5	5
0.99	5	14	10	8	7	6	6	6	6
0.99	6	16	11	9	8	7	7	7	7
0.99	7	18	12	10	9	8	8	8	8
0.99	8	20	14	11	10	9	9	9	9
0.99	9	21	15	13	12	10	10	10	10
0.99	10	23	16	14	13	11	11	11	11

Table 2. Operating characteristic function values for the sampling plan (n, c = 2, t / μ_0) for a given probability P^* with β = 0.9, α = 25, and θ = 0.1

			μ / μ_0					
P^*	n	t / μ_0	2	4	6	8	10	12
0.75	38	0.628	0.947240	0.999891	1	1	1	1
0.75	18	0.942	0.918498	0.999247	0.999989	1	1	1
0.75	11	1.257	0.903173	0.998380	0.999945	0.999998	1	1
0.75	8	1.571	0.885158	0.997250	0.999862	0.999990	0.999999	1
0.75	5	2.356	0.839510	0.993433	0.999465	0.999934	0.999990	0.999998
0.75	4	3.141	0.775634	0.986705	0.998595	0.999780	0.999956	0.999990
0.75	4	3.927	0.592870	0.961674	0.994901	0.999054	0.999780	0.999940
0.75	3	4.712	0.709664	0.973527	0.996235	0.999244	0.999809	0.999943
0.90	15	0.628	0.803512	0.995847	0.999854	0.999994	1	1
0.90	9	0.942	0.707525	0.987677	0.999152	0.999917	0.999990	0.999999
0.90	6	1.257	0.693104	0.982645	0.998404	0.999786	0.999964	0.999993
0.90	5	1.571	0.616632	0.970560	0.996670	0.999464	0.999892	0.999975
0.90	4	2.356	0.415407	0.917778	0.986698	0.997182	0.999268	0.999780
0.90	3	3.141	0.470690	0.916564	0.984395	0.996237	0.998899	0.999629
0.90	3	3.927	0.280550	0.824554	0.958699	0.988464	0.996234	0.998609
0.90	3	4.712	0.156361	0.709664	0.916532	0.973527	0.990525	0.996235
0.95	10	0.628	0.642997	0.983142	0.998809	0.999882	0.999986	0.999998
0.95	6	0.942	0.580140	0.968492	0.996656	0.999499	0.999906	0.999980
0.95	5	1.257	0.430858	0.932675	0.990602	0.998244	0.999594	0.999891
0.95	4	1.571	0.415199	0.917710	0.986683	0.997178	0.999267	0.999779
0.95	3	2.356	0.367241	0.874379	0.973527	0.993108	0.997864	0.999244
0.95	3	3.141	0.156422	0.709741	0.916564	0.973539	0.990530	0.996237
0.95	3	3.927	0.060273	0.527602	0.824554	0.934288	0.973517	0.988464
0.95	3	4.712	0.022068	0.367241	0.709664	0.874379	0.943854	0.973527
0.99	9	0.628	0.394149	0.942665	0.993970	0.999152	0.999855	0.999972
0.99	6	0.942	0.277930	0.886543	0.982717	0.996656	0.999214	0.999788
0.99	5	1.257	0.166265	0.799617	0.960075	0.990602	0.997390	0.999175
0.99	4	1.571	0.167046	0.775417	0.949211	0.986683	0.995931	0.998592
0.99	3	2.356	0.156361	0.709664	0.916532	0.973527	0.990525	0.996235
0.99	3	3.141	0.043345	0.470690	0.788129	0.916564	0.965148	0.984395
0.99	3	3.927	0.011087	0.280550	0.627988	0.824554	0.916507	0.958699
0.99	3	4.712	0.002727	0.156361	0.470596	0.709664	0.845317	0.916532

Table 3. Minimum ratio of the true mean life to specified mean life for the acceptance of a lot with producer's risk of 0.05 with β = 0.9, α = 25, and θ = 0.1

		t / μ_0							
P^*	c	0.628	0.942	1.257	1.571	2.356	3.141	3.927	4.712
0.75	0	3.537	4.233	4.933	5.561	7.141	7.117	8.897	10.676
0.75	1	2.393	2.648	2.946	3.201	3.862	4.325	4.027	4.832
0.75	2	2.018	2.195	2.295	2.407	2.676	3.011	3.764	3.433
0.75	3	1.818	1.978	2.071	2.166	2.405	2.416	3.020	2.807
0.75	4	1.698	1.817	1.879	2.022	2.242	2.423	2.592	2.446
0.75	5	1.618	1.710	1.800	1.852	1.975	2.147	2.312	2.774
0.75	6	1.559	1.656	1.703	1.794	1.924	1.951	2.112	2.534
0.75	7	1.515	1.595	1.664	1.697	1.882	2.006	1.962	2.354
0.75	8	1.479	1.547	1.603	1.668	1.749	1.872	2.110	2.212
0.75	9	1.445	1.509	1.554	1.602	1.733	1.764	1.993	2.098
0.75	10	1.422	1.477	1.537	1.586	1.637	1.816	1.897	2.004
0.90	0	5.643	6.669	7.620	9.524	10.676	14.233	17.794	21.351
0.90	1	3.400	3.839	4.121	4.326	6.488	6.441	8.053	9.663
0.90	2	2.683	3.086	3.230	3.569	4.516	4.577	5.723	6.866
0.90	3	2.346	2.597	2.823	2.843	3.624	3.742	4.678	5.613
0.90	4	2.149	2.314	2.587	2.723	3.110	3.260	4.076	4.891
0.90	5	2.018	2.129	2.275	2.404	2.774	2.944	3.680	4.416
0.90	6	1.890	2.077	2.190	2.380	2.534	2.717	3.397	4.076
0.90	7	1.824	1.968	2.009	2.188	2.354	3.138	3.183	3.819
0.90	8	1.772	1.884	1.972	2.038	2.531	2.949	3.014	3.616
0.90	9	1.706	1.816	1.942	2.057	2.391	2.797	2.877	3.452
0.90	10	1.674	1.761	1.833	1.947	2.276	2.671	2.763	3.315
0.95	0	7.393	10.003	11.430	14.285	16.013	21.349	26.691	32.026
0.95	1	4.143	4.632	5.192	6.489	7.247	9.662	12.080	14.494
0.95	2	3.270	3.631	4.283	4.517	5.150	6.866	8.584	10.299
0.95	3	2.735	3.173	3.412	3.625	4.210	5.612	7.016	8.419
0.95	4	2.530	2.689	2.908	3.111	3.668	4.890	6.114	7.336
0.95	5	2.309	2.558	2.886	3.221	3.312	4.415	5.520	6.623
0.95	6	2.152	2.307	2.613	2.927	3.801	4.075	5.095	6.113
0.95	7	2.034	2.258	2.408	2.705	3.530	3.818	4.774	5.728
0.95	8	2.000	2.097	2.247	2.532	3.318	3.616	4.520	5.424
0.95	9	1.921	2.078	2.300	2.392	3.147	3.451	4.315	5.177
0.95	10	1.856	1.963	2.180	2.276	3.005	3.314	4.144	4.972

Table 3 (continued).

		t / *μ*0							
P^*	c	0.628	0.942	1.257	1.571	2.356	3.141	3.927	4.712
0.99	0	9.857	13.337	15.240	19.047	21.351	28.465	35.588	42.702
0.99	1	5.524	6.176	6.923	8.652	9.663	12.882	16.106	19.325
0.99	2	4.114	4.841	5.710	6.023	6.866	9.154	11.445	13.732
0.99	3	3.463	3.845	4.549	4.833	5.613	7.483	9.355	11.225
0.99	4	3.086	3.266	3.878	4.148	4.891	6.520	8.152	9.781
0.99	5	2.710	3.159	3.437	3.699	4.416	5.887	7.360	8.831
0.99	6	2.554	2.854	3.122	3.379	4.076	5.434	6.793	8.151
0.99	7	2.437	2.624	2.886	3.139	3.819	5.091	6.365	7.637
0.99	8	2.346	2.626	2.701	2.950	3.616	4.821	6.027	7.232
0.99	9	2.195	2.467	2.823	3.189	3.452	4.601	5.753	6.903
0.99	10	2.143	2.334	2.680	3.035	3.315	4.419	5.525	6.629

Conclusions

An acceptance sampling plan was developed for when the life test is truncated at a pre-determined time and the life time of the test follow a three-parameter Lindley distribution. Based on the same conditions, in order to assert a specified mean life with a given confidence level, the three-parameter Lindley distribution results in smaller sample sizes than some other distributions used in acceptance sampling in general. However, the researchers can use the suggested sampling plans easily.

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